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Stock Assessment of the Return of Late-Run Chinook Salmon to the Kenai River, 1993

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ABSTRACT

The estimated total return of late-run chinook salmon *Oncorhynchus tshawytscha* to the Kenai River in 1993 was 64,583. This estimate does not include fish harvested in the recreational marine fishery near Deep Creek, which will be available later in 1994 from the Statewide Harvest Survey. The total harvest in marine gill net fisheries, commercial drift and set net fisheries, and the Kenaitze Indian educational set gill net fishery was 14,909. The total inriver return of late-run chinook salmon estimated through hydroacoustic techniques was 49,674. The estimated angler-effort and harvest measured from a creel survey during the late chinook salmon run were 293,908 angler-hours and 15,279 chinook salmon, respectively.

Release mortality was estimated at 363 fish. Spawning escapement was 34,032 and met spawning requirements stipulated in the management plan. The predominant age class of the commercial harvest, inriver return, and recreational harvest was age-1.4 fish.

Migratory timing models were used to project spawning escapement during the 1993 fishery. No additional restrictions to the fishery were required to achieve escapement goals. A relatively strong return allowed for an additional 4 days of recreational fishing in August.

A sibling model was used to forecast the 1994 return of chinook salmon to the Kenai River at 66,876 (SE = 19,021) fish.

Production from the 1984 brood did little better than replacement. However, production from the 1985 brood was 1.86 returning fish-per-spawner. Production from the 1986 brood will approximate replacement. Production from the 1987 brood has been 1.63 returning fish-per-spawner with age 7 and 8 to return in 1994 and 1995, respectively.

KEY WORDS: Kenai River, chinook salmon, *Oncorhynchus tshawytscha*, creel survey, effort, harvest, migratory timing, sibling ratios, brood tables.

INTRODUCTION

The largest freshwater recreational fishery in Alaska occurs in the Kenai River with an average of nearly 350,000 angler-days of effort each year from 1983-1992 (Mills 1984-1993). This represents approximately 15% of the state's recreational fishing effort. The majority of the angler-effort occurs in the section of the river between the Soldotna Bridge and Cook Inlet (Figure 1) during a fishery directed primarily at returning chinook salmon *Oncorhynchus tshawytscha* during May, June, and July.

Two stocks of Kenai River chinook salmon have long been recognized: an early run which enters the river from mid-May through June, and a late run which enters the river from late June through early August (Burger et al. 1985; Bendock and Alexandersdottir 1992). Early-run fish are destined primarily for tributary spawning locations although some mainstem spawning also occurs. Late-run fish are destined almost exclusively for mainstem spawning locations and are the focus of this report.

Prior to 1970, the recreational fishery in the Kenai River was composed of shorebased anglers targeting sockeye salmon *O. nerka* in July and coho salmon *O. kisutch* in August and early September. In 1973, large numbers of anglers began experimenting with a fishing method that involved bouncing brightly colored terminal gear along the river bottom from a drifting boat. This technique had been used effectively by anglers fishing for chinook salmon on rivers in the Pacific Northwest. It proved to be a very effective method for catching chinook salmon on the Kenai River, and the fishery expanded rapidly (Figure 2).

As fisheries targeting both the early and late runs continued to grow during the early 1980s, concerns about overexploitation were heightened. In 1988, the Board of Fisheries (BOF) adopted management plans for the early and late returns of chinook salmon to the Kenai River (McBride et al. 1989). These plans, which have been in effect since 1989, stipulate both escapement goals for which the fisheries will be managed, and the manner in which these fisheries are to be managed in the event of a conservation shortfall (Figure 3; Appendix A).

Sport fishing regulations for chinook salmon in the Kenai River are detailed in the management plans, and are now among the most restrictive in Alaska. The recreational fishery for late-run chinook salmon on the Kenai River is 1 July through 31 July. Only the mainstem Kenai River between the outlet of Skilak Lake and Cook Inlet (Figure 1) is open to fishing for chinook salmon. The daily bag and possession limits are one chinook salmon per day greater than 41 cm (16 in) total length and a seasonal limit of two chinook salmon greater than 41 cm. Harvest of chinook salmon less than 41 cm is limited only by the daily bag limit of 10. An amendment to the late-run management plan, which went into effect during the 1991 season, provides for retention of large fish, 132 cm (52 in) or larger, if hook-and-release fishing is imposed (termed "trophy fishing").

Since 1993, fishing from boats downstream from the outlet of Skilak Lake is prohibited on Mondays in July. Anyone retaining a chinook salmon that is 41 cm in length or greater is prohibited from fishing from a boat in the Kenai River for the remainder of that day. Anglers employing guides are restricted

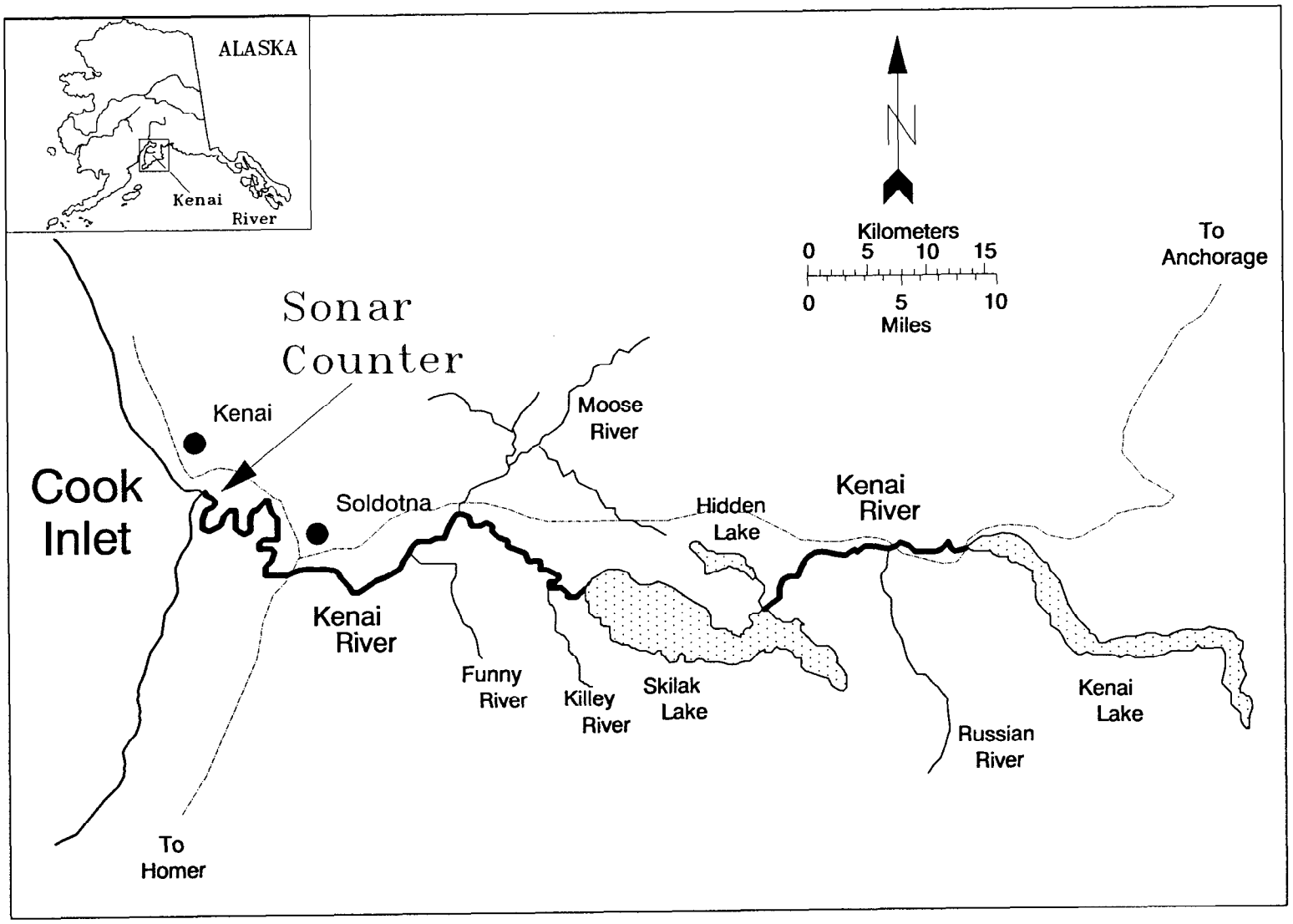

Figure 1. Map of Kenai River drainage.

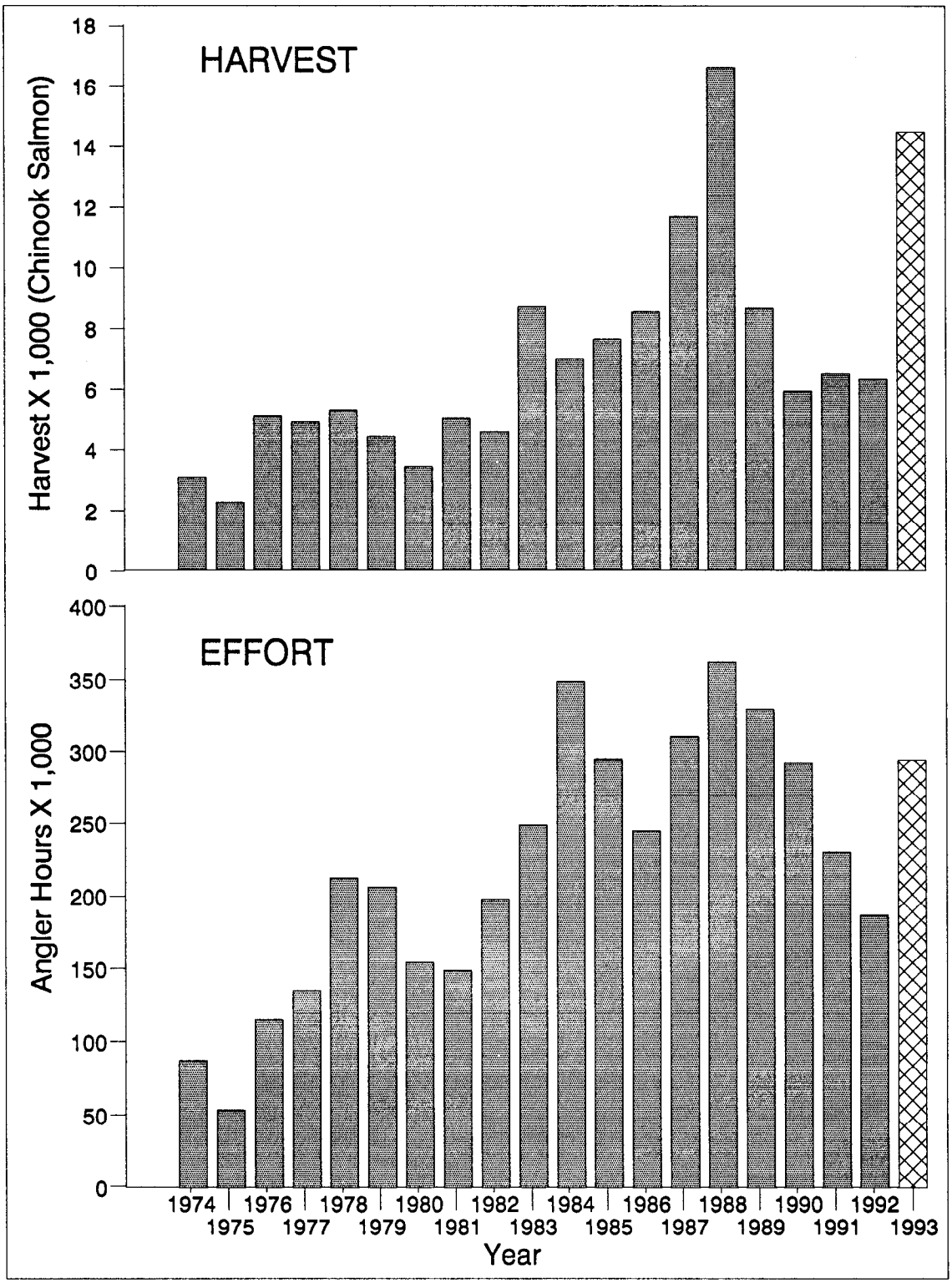

Figure 2. Historical harvest and effort in the recreational fishery for late-run chinook salmon, Kenai River, 1974-1993.

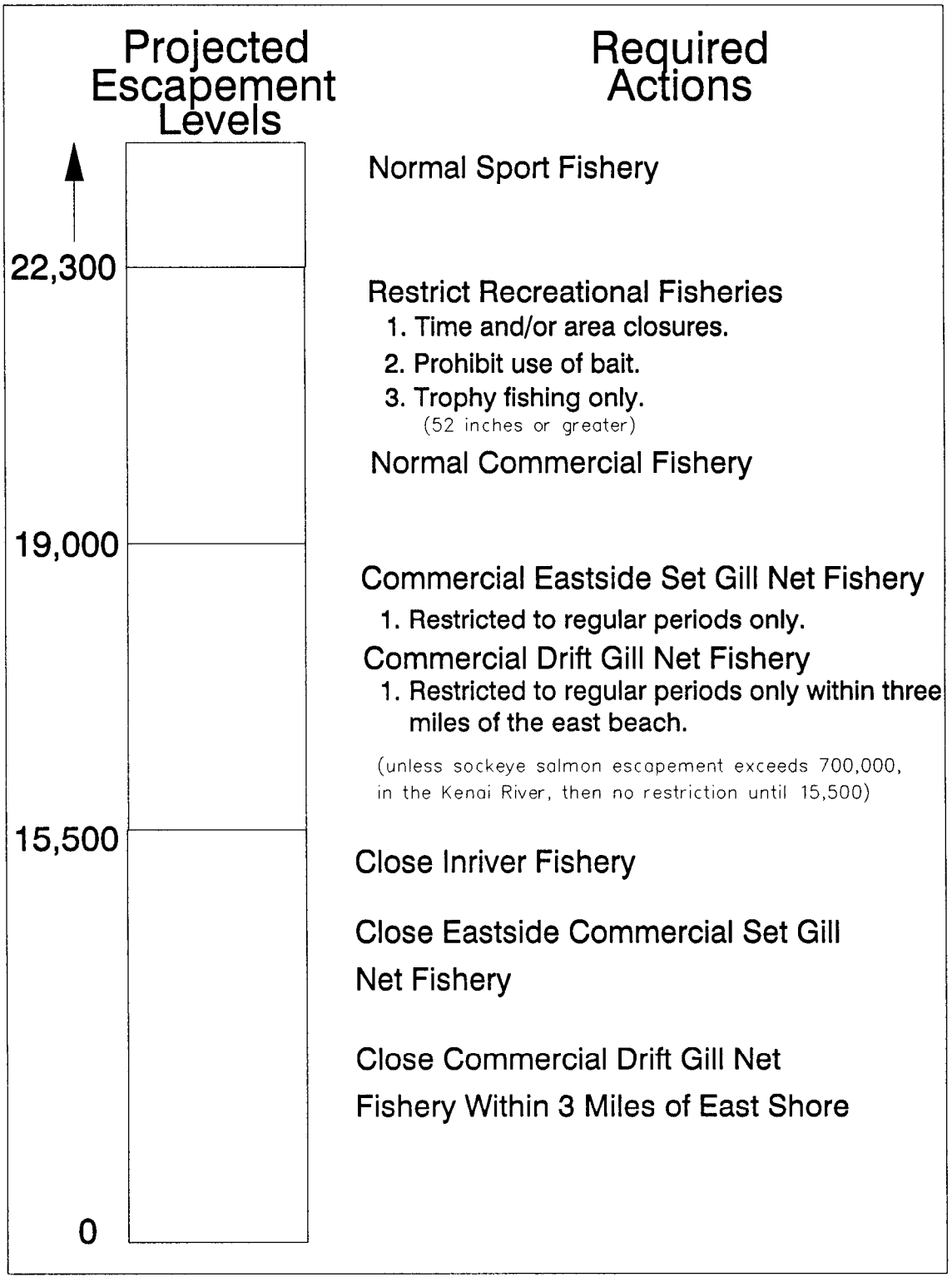

Figure 3. Escapement levels and required actions according to the Kenai River Late King Salmon Management Plan.

further: during July, fishing from a guided boat is allowed only between 0600 and 1800 hours, and on Tuesday through Saturday only.

Implementation of the management plans hinges upon the department's ability to project the strength of the current year's return early in the season. A comprehensive stock assessment program, which was initiated in the mid-1980s in response to the growing chinook fisheries, and creel surveys, which have been conducted on the Kenai River since 1974 (Hammarstrom 1975), are the primary means of collecting the data necessary for implementing the plans. The objectives of these continuing studies are two-fold: to assess production by estimating harvest and abundance by age and inriver returns (Hammarstrom and Larson 1986)[1]; and to model run timing, including migratory timing estimates of effort, harvest, and abundance. Because of the diversity and complexity of these studies, results of each study are published in separate reports.

This report compiles statistics for the 1993 late run, including estimates of inriver return, fishery parameters, and escapement. The estimates are compared to historic data and their application to the 1993 return are discussed. Finally, a forecast of the 1994 return is presented.

Previous studies of the chinook salmon fisheries in the Kenai River include the following: Hammarstrom (1975-1981, 1988-1991, 1992a and b, 1993a and b); Hammarstrom and Larson (1982-1984, 1986); Hammarstrom et al. (1985); Conrad and Hammarstrom (1987). Details of the 1993 creel survey of the recreational fishery are reported by Hammarstrom (*In prep*). In addition, angler-effort and harvest by species for the recreational fishery have been estimated by Mills (1979-1993) via postal questionnaire. Rationale for the escapement goals and migratory timing data to implement the management plans are contained in McBride et al. (1989). Bendock and Alexandersdottir (1992) estimated hooking mortality for the Kenai River chinook salmon recreational fisheries. Estimates of total return by age have been summarized through 1990 by Sonnichsen and Alexandersdottir (1991).

SUMMARY OF HISTORICAL DATA

Harvest and Escapement

Late-run Kenai River chinook salmon are harvested at several locations during their spawning migration. Chinook salmon harvested in the marine waters of Cook Inlet after 1 July are assumed to be of Kenai River origin because chinook salmon of the Kasilof River, the only other population of late-run chinook salmon in Cook Inlet, are believed to be much less abundant than the Kenai River population (McBride et al. 1985). The first significant harvest of late-run chinook occurs in the recreational marine fishery in the vicinity

[1] To clarify terms, inriver return refers to all fish that are counted by sonar in the Kenai River. Total return refers to all late-run Kenai River chinook salmon harvested in Upper Cook Inlet marine fisheries plus the inriver return. Escapement (fish that survive all fisheries and are potential spawners) is estimated by subtracting total mortalities from the recreational fishery (harvest plus hook-and-release mortalities) from the inriver return.

of Deep Creek. This harvest is estimated by postal questionnaire, the results of which are unavailable until the following year (Mills 1979-1993). The estimates do not differentiate between early and late runs and thus the harvest is apportioned based on the historical average proportion determined by creel surveys conducted onsite from 1973-1985 (Hammarstrom 1975-1981; Hammarstrom and Larson 1982-1984, 1986; Hammarstrom et al. 1985).

Additional harvest occurs in the commercial set gill net fishery along the eastern shore of Cook Inlet and to a lesser degree in the commercial drift gill net fishery. Total commercial harvest is determined from sales receipts (fish tickets) (ADF&G *Unpublished*). Both of these commercial fisheries target sockeye salmon and the chinook salmon harvest is bycatch. The commercial fisheries are managed according to the Upper Cook Inlet Salmon Management Plan.

A single net educational fishery for members of the Kenaitze Indian tribe has been authorized since 1989, and total harvest is reported to the department per the terms of the permit.

Inriver returns have been estimated annually since 1984. Two methods have been employed: a tag/recapture program from 1984-1990 (Hammarstrom and Larson 1986; Conrad and Larson 1987; Conrad 1988; Carlon and Alexandersdottir 1989; Alexandersdottir and Marsh 1990); and a hydroacoustic (sonar) program from 1984-1993 (Burwen and Skvorc *In prep* a, b, c, and d; and Burwen *In prep*). Since 1987, sonar has provided the best estimate of the inriver return. The tag/recapture program was last conducted in 1990. Since 1984, the inriver return has averaged 40,374 fish.

To estimate abundance by age, the age/sex composition of the inriver return is estimated. Prior to 1991, scale samples collected from chinook salmon captured with large mesh gill nets during the tag/recapture studies provided the samples for this analysis. Although the tagging program was discontinued in 1991, age, sex and length samples are still collected using gill nets.

The commercial harvest in Cook Inlet is sampled for age, sex and size composition by the Commercial Fisheries Division of ADF&G, as described by Waltemyer (*In prep*). These data provide estimates of the numbers of chinook salmon by age, sex and size in the commercial set gill net, drift gill net, and subsistence gill net harvest.

The age, sex and size composition of the sport harvest is estimated from samples collected during angler interviews conducted in the creel survey (Hammarstrom 1993b).

Mortality due to hook-and-release fishing on late-run fish was estimated to be 13.2% for small males (< 750 mm); 5.0% for large males (> 750 mm); and 5.0% for females (Bendock and Alexandersdottir 1992). However, it is not possible to measure the size or sex composition of the release component. Therefore, a grand average of the estimated mortality rates on late-run fish (8.3%) was used as a reasonable estimate for this stock. This approach introduces an unknown bias because of the higher mortality for small males and the tendency of anglers to release smaller fish. Age, sex and size composition of the fish that were released and died was assumed equal to that of the inriver return.

Brood and Sibling Relationships

Chinook salmon in the Kenai River are managed to achieve optimum sustained production. In 1988, spawning requirements were computed to sustain levels of production realized during the years 1984 to 1988. These escapement goals were based on limited information from the Kenai River and the experiences of other researchers working with chinook salmon on the west coast of North America (McBride et al. 1989). Total return data are being compiled to assess production and refine these escapement goals. A good stock-recruit analysis requires data that span decades, since one year's return must be compared to returns from parent generations many years earlier.

A predictable relationship between consecutive-year returns of the same brood (i.e. sibling relationships) has been established for the late run (Sonnichsen and Alexandersdottir 1991). As a result, mean sibling ratios (the ratio of one age to one or more younger ages for a brood) for years with complete return data were used to predict returns for 1990-1993. By using mean sibling ratios of those years for which complete return data are available, models were developed to predict the returns for 1990-1993 (Sonnichsen and Alexandersdottir 1991; Hammarstrom 1992a, 1993a).

Migratory Timing

Four models for predicting the entry pattern of chinook salmon into the Kenai River were evaluated in 1993. Data used in the models were: (1) inriver return, measured by daily gill net CPUE for 1984 to 1986 and by daily sonar counts for 1987 to 1992; and (2) inriver recreational fishery statistics, including angler effort, harvest, and catch.

For the mean timing model, historic cumulative daily proportions of inriver return were used to generate a migratory timing model that was applied to the 1993 data to predict total inriver return for 1993 (McBride et al. 1989). Cumulative daily proportions of the inriver return for the years 1985-1992 were averaged to project total inriver return for 1993 (Appendix B1). Cumulative daily proportions of recreational effort, harvest, and catch for the years 1984-1992 were also used to generate a model that projected harvest and catch for 1993 (Appendices B2-B7).

The second model was based on the occurrence of the neap tide (smallest exchange of tidal waters). Fishermen, both commercial and recreational, maintain that salmon generally move in relation to the tidal cycles. Many fishermen believe salmon migrate through Cook Inlet with the larger tides of the lunar cycle. Davis et al. (1994) noted that peak hourly counts of sockeye salmon in the Crescent River, a tributary to Cook Inlet, generally occurred following high tides in 1992. Hourly chinook salmon counts tend to increase with the incoming tide at the sonar site in the intertidal waters of the Kenai River (D. Burwen, Alaska Department of Fish and Game, Anchorage, personal communication). Some of the highest tidal exchanges in the world have been recorded for Cook Inlet. If tide cycles do influence salmon migration, it was felt that Cook Inlet would manifest this influence. A cursory examination of run timing data suggested that there was a correlation of increased numbers of chinook salmon entering the Kenai River with decreasing sizes of tidal exchanges in July.

On a daily basis, the end-of-season inriver return was projected by dividing the 1993 cumulative sonar count by the historic mean cumulative proportion as related to the neap tide. For example, if the neap tide occurred on 15 July, then the 1 July count would be listed as the count on day -15 and the count on 25 July would be listed on day +10. For each year, 1987-1992, cumulative sonar counts were adjusted to the neap date. Escapement was projected by subtracting the projected fishing mortality (inriver harvest + hook-and-release mortality) from the projected inriver return. Although projections were made from the commencement of the fishery, precision of the estimates was insufficient to detect significant deviations from historic performance until mid-July.

The third model examined to predict the entry of chinook salmon into the Kenai River was based on a curve-fit program developed by F. Jamsen (Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development Division) to predict the entry of sockeye salmon into Cook Inlet. Run timing data for chinook salmon were substituted for sockeye salmon data in the data base. Briefly, this program compares current cumulative chinook salmon sonar counts with historical run timing data and estimates a total inriver return using each year's entry pattern. The model then ranks each year based on the mean sum of squares error analysis (MSE). The "best-fit" year is then selected as the model year. This analysis is updated daily, thus the model year and estimated inriver return may change often throughout the season.

A fourth migratory timing model was examined postseason to predict the end-of-season harvest of chinook salmon by the commercial set gill net fishery along the eastern shore of Cook Inlet based on the historic cumulative proportion of total harvest by date. This end-of-season total harvest was then expanded by the average measured exploitation rate (1984-1993) in that fishery to predict the total inriver return.

Of the three models examined prior to the 1993 season (mean timing, neap tide, and curve-fit), no one model performed significantly better than another. However, the neap tide model was the only model that accurately predicted the early-run timing of 1989 (Figure 4). Since the July 1993 neap tide date was similar to the neap tide date that occurred in 1989 (both were very early), this was selected as the inseason model for 1993.

ASSESSMENT OF THE 1993 LATE RETURN

Effort and Harvest of Late-Run Chinook Salmon

Estimated harvest from the recreational marine fishery near Deep Creek in 1993 will not be available until late 1994. Harvest from the late run in this fishery has averaged approximately 1,000 chinook salmon annually (Mills 1984-1993).

The commercial harvest in the set gill net fishery along the eastern shore of Cook Inlet was 14,002 fish. This is the largest harvest since 1987 and approximately 17% greater than the 1984 to 1992 mean of 11,980 fish. Harvest of chinook salmon in the drift gill net fishery was 751 fish, well below the historical mean. A total of 129 chinook salmon were retained for personal use

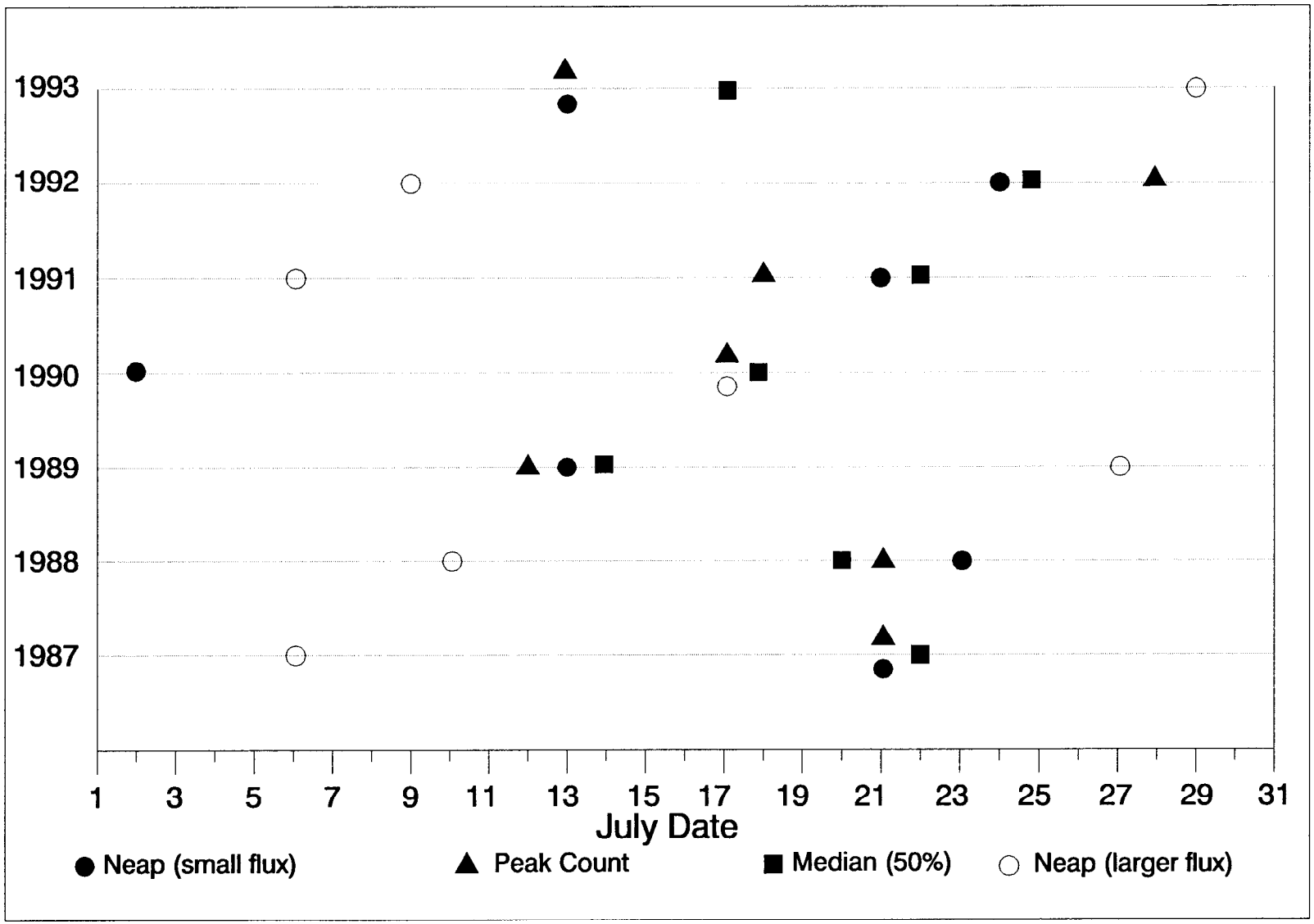

Figure 4. July dates for small flux and large flux July neap tides, the median date of fish passage, and the peak date of fish passage for Kenai River chinook salmon, 1987-1993.

from the combined commercial set and drift gill net harvest. A total of 915 fish with readable scales was sampled from the commercial set gill net harvest (Table 1). Most of the harvest was composed of age-1.4 fish (57.9%), followed by age-1.3 (20.9%), and -1.2 (13.0%) fish.

In 1993, the Kenaitze Indian Tribe conducted a single net educational fishery during the months of July and August. The late-run chinook salmon harvest from this fishery was 27 fish.

The 1993 inriver recreational fishery for late-run chinook salmon started 1 July. Angler effort during the fishery for late-run chinook salmon was estimated at 293,908 angler-hours (SE = 8,670) (Hammarstrom *In prep*). The estimated harvest of 15,279 (SE = 620) was nearly 2.3 times greater than the 1974-1992 average. Catch was estimated to be 19,660 (SE = 787). Anglers employing professional guides accounted for 52% of the harvest and 31% of the effort (Table 2).

A total of 689 fish with readable scales was sampled from the recreational harvest. Because there was no significant difference in age composition between the first and second half of July (χ^2 = 7.56, df = 4, α = 0.05, P > 0.10), samples were combined. The majority of the harvest was age class 1.4 (85.6%) (Table 3). Historical comparison of the age composition of the late-run recreational harvest is presented in Table 4 (1976-1993).

In 1993, an estimated 22% of the catch was released. Since 1986, the first year that estimates of total catch in the recreational fishery were available, an average of 27% of the catch has been released. In 1993, release mortality was estimated at 363 fish (SE = 153). Historical hook-and-release mortality estimates are presented in Table 5. The age and sex composition of the hook-and-release mortality was assumed equal to that of the inriver return (Table 6).

Inriver Return

Counting of fish by sonar began 16 May and continued through the early and late runs (Burwen *In prep*). Inriver return from 1 July through 10 August was 49,674 fish (Table 7). The 1993 inriver return was the third largest measured since 1984, and was 26% greater than the 1984-1992 mean of 39,341. Run timing compared to the 1985-1992 mean appears in Figure 5.

A total of 350 chinook salmon were captured in gill net test fishing during the late run (Table 8). There was a significant difference in the age composition between the first half of the run and the second half (χ^2 = 26.83, df = 4, α = 0.05, P < 0.001). The inriver return was predominantly age 1.4 (71.6%) followed by age class 1.3, 1.2, and 1.5 (14.1%, 8.1%, 5.7%, respectively). Total inriver return by age and historical age compositions (1986 to 1993) appear in Table 9.

Escapement and Total Return

Spawning escapement by age class was estimated by subtracting total inriver fishing mortality from the inriver return. In 1993, an estimated 34,032 (SE = 639) chinook salmon escaped all fisheries (Table 10). The majority (65.4%) of

Table 1. Estimates by age class of the number of late-run chinook salmon harvested in the Upper Subdistrict commercial set and drift gill net fisheries, personal use/subsistence fisheries, and educational fisheries, Upper Cook Inlet, Alaska, 1993.

	Age Class								
	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Total
Males									
Sample Size	25	75	118	1	284	3	21	2	529
Percent	2.7	8.2	12.9	0.1	31.0	0.3	2.3	0.2	57.8
SE Percent	0.5	0.9	1.1	0.1	1.5	0.2	0.5	0.2	1.6
Harvest	407	1,222	1,923	16	4,628	49	342	33	8,620
SE Harvest	80	135	165	16	228	28	74	23	244
Females									
Sample Size	2	44	73	0	246	3	16	2	386
Percent	0.2	4.8	8.0	0.0	26.9	0.3	1.7	0.2	42.2
SE Percent	0.2	0.7	0.9	0.0	1.5	0.2	0.4	0.2	1.6
Harvest	33	717	1,189	0	4,008	49	261	32	6,289
SE Harvest	23	106	134	0	219	28	65	23	244
Combined									
Sample Size	27	119	191	1	530	6	37	4	915
Percent	3.0	13.0	20.9	0.1	57.9	0.7	4.0	0.4	100.0
SE Percent	0.6	1.1	1.3	0.1	1.6	0.3	0.7	0.2	
Harvest	440	1,939	3,112	16	8,636	98	603	65	14,909
SE Harvest	83	166	200	16	243	40	97	33	

Table 2. Historical summary of harvest, angler effort and harvest rate in the recreational fishery for late-run chinook salmon, Kenai River, 1974-1993.

Year	Harvest			Effort in Angler Hours			Harvest per Hour		
	Unguided	Guided	Total	Unguided	Guided	Total	Unguided	Guided	Total
1974			3,225			87,162			0.037
1975			2,355			53,523			0.044
1976			5,353			114,795			0.047
1977			5,148			135,082			0.038
1978			5,578			212,217			0.026
1979			4,634			205,887			0.023
1980			3,608			154,435			0.023
1981	2,755	2,530	5,285	112,569	36,727	149,296	0.024	0.069	0.035
1982	2,413	2,397	4,810	146,947	50,828	197,775	0.016	0.047	0.024
1983	4,064	5,110	9,174	197,324	51,195	248,519	0.021	0.100	0.037
1984	4,448	2,928	7,376	302,915	45,664	348,579	0.015	0.064	0.021
1985	5,010	3,045	8,055	248,517	45,936	294,453	0.020	0.066	0.027
1986	5,458	3,546	9,004	191,597	52,843	244,440	0.028	0.067	0.037
1987	6,361	5,966	12,327	231,511	79,329	310,840	0.027	0.075	0.040
1988	8,103	9,409	17,512	266,578	95,181	361,759	0.030	0.099	0.048
1989	3,799	5,328	9,127	231,085	97,966	329,051	0.016	0.054	0.028
1990 [a]	2,439	3,808	6,247	190,743	101,223	291,966	0.013	0.038	0.022
1991	2,985	3,864	6,849	147,293	82,706	229,999	0.020	0.047	0.030
1992 [a]	2,504	4,176	6,680	112,091	75,324	187,415	0.024	0.064	0.039
Mean	3,872	3,722	6,617	183,013	58,209	207,860	0.020	0.056	0.031
1993	7,413	7,866	15,279	201,695	92,213	293,908	0.037	0.085	0.052

[a] Harvest per hour only for periods open to retention of chinook salmon.

Table 3. Estimates by age class of the number of late-run chinook salmon harvested in the recreational fishery on the Kenai River, 1993.

	Age Class					
	1.2	1.3	1.4	1.5	Other	Total
Males						
Sample Size	10	22	245	20	6	303
Percent	1.5	3.2	35.6	2.9	0.9	44.0
SE Percent	0.5	0.7	1.8	0.6	0.4	1.9
Harvest	222	488	5,433	443	133	6,719
SE Harvest	70	104	355	99	54	397
Females						
Sample Size	3	17	345	20	1	386
Percent	0.4	2.5	50.1	2.9	0.1	56.0
SE Percent	0	0.6	1.9	0.6	0.1	1.9
Harvest	66	377	7,651	444	22	8,560
SE Harvest	38	92	426	99	22	452
Combined						
Sample Size	13	39	590	40	7	689
Percent	1.9	5.7	85.6	5.8	1.0	100.0
SE Percent	0.5	0.9	1.3	0.9	0.4	
Harvest	288	865	13,084	887	155	15,279
SE Harvest	80	139	569	141	59	620

Table 4. Estimates by age class of the number of late-run chinook salmon harvested in the recreational fishery on the Kenai River, 1976-1993.

	Age Class										
	1.1	1.2	1.3	1.4	1.5	1.6	2.2	2.3	2.4	2.5 Other	Total
1976											
Percent	10.7	27.0	18.3	40.1	3.6		0.3				100.0
Harvest	481	1,210	817	1,794	160		15				4,477
SE Harvest	79	114	99	125	48		15				
1977											
Percent		11.5	41.4	44.8	1.7				0.6		100.0
Harvest		592	2,130	2,307	89				30		5,148
SE Harvest		125	193	195	51				30		
1978											
Percent		12.6	8.0	77.7	1.7						100.0
Harvest		701	446	4,335	96						5,578
SE Harvest		68	73	89	0						
1979											
Percent		15.1	17.8	54.8	12.3						100.0
Harvest		698	825	2,540	571						4,634
SE Harvest		195	209	272	180						
1980											
Percent		21.2	21.5	49.8	7.5						100.0
Harvest		763	776	1,797	272						3,608
SE Harvest		88	89	108	57						
1981											
Percent		12.8	22.2	62.4	2.6						100.0
Harvest		678	1,174	3,297	136						5,285
SE Harvest		164	204	238	78						

-continued-

Table 4. (Page 2 of 3).

	Age Class										
	1.1	1.2	1.3	1.4	1.5	1.6	2.2	2.3	2.4	2.5 Other	Total
1982											
Percent		11.8	26.0	58.8	1.7					1.7	100.0
Harvest		566	1,253	2,829	81					81	4,810
SE Harvest		143	194	218	57					57	
1983											
Percent		3.7	4.9	86.4	2.5				2.5		100.0
Harvest		340	453	7,927	227				227		9,174
SE Harvest		194	222	351	159				159		
1984											
Percent		8.8	16.0	62.5	12.7						100.0
Harvest		650	1,179	4,610	937						7,376
SE Harvest		95	122	162	111						
1985											
Percent		3.9	12.8	73.5	8.0					1.8	100.0
Harvest		315	1,031	5,923	646					140	8,055
SE Harvest		73	125	166	102					49	
1986											
Percent	0.4	10.1	39.0	45.2	5.3						100.0
Harvest	37	913	3,507	4,072	475						9,004
SE Harvest	26	131	266	289	94						458
1987											
Percent	0.4	1.0	22.8	72.7	3.1						100.0
Harvest	51	127	2,787	8,892	380						12,237
SE Harvest	36	57	292	611	99						769

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Table 4. (Page 3 of 3).

	Age Class										
	1.1	1.2	1.3	1.4	1.5	1.6	2.2	2.3	2.4	2.5 Other	Total
1988											
Percent	0.7	0.2	3.4	78.6	17.1						100.0
Harvest	126	42	589	13,766	2,989						17,512
SE Harvest	73	42	159	887	368						1,036
1989											
Percent		1.0	10.9	71.3	15.8				1.0		100.0
Harvest		90	994	6,507	1,446				90		9,127
SE Harvest		90	291	585	345				90		582
1990											
Percent	0.6	9.7	15.8	62.2	11.7						100.0
Harvest	37	605	989	3,883	733						6,247
SE Harvest	26	109	142	322	121						445
1991											
Percent		4.9	11.7	76.2	6.3			0.9			100.0
Harvest		338	799	5,221	430			61			6,849
SE Harvest		101	155	369	114			43			410
1992											
Percent	0.5	2.0	15.4	76.1	6.0						100.0
Harvest	33	133	1,030	5,085	399						6,680
SE Harvest	33	66	185	405	115						462
1993											
Percent		1.9	5.7	85.6	5.8		0.6	0.3	0.1		100.0
Harvest		288	865	13,084	887		89	44	22		15,279
SE Harvest		80	139	569	141		44	31	22		620

Table 5. Estimates of the number of late-run chinook salmon mortalities attributable to hook-and-release fishing, Kenai River, 1986-1993.

Year	Sport Catch	Sport Harvest	Number Released	SE Released	Percent Mortality [a]	SE Percent	Hook-and-Release Mortality	SE Mortality
1986	15,331	9,004	6,327	872	8.3 (E)	3.39	522	220
1987	16,701	12,237	4,464	1,214	8.3 (E)	3.39	368	174
1988	23,238	17,512	5,726	1,590	8.3 (E)	3.39	472	225
1989	12,210	9,127	3,083	1,097	10.6 (M)	3.30	327	148
1990	8,637	6,247	2,390	709	5.9 (M)	3.30	141	65
1991	8,091	6,849	1,242	248	8.3 (E)	3.39	103	46
1992	10,394	6,680	3,714	409	8.3 (E)	3.39	308	130
1993	19,660	15,279	4,381	486	8.3 (E)	3.39	363	153

[a] (E) Estimated as the mean of the 1989 and 1990 mortality ratios (Bendock and Alexandersdottir 1992).
(M) Measured.

Table 6. Estimates by age class of the number of late-run chinook salmon that died as a result of hook-and-release fishing in the recreational fishery on the Kenai River, 1993.

	Age Class					
	1.2	1.3	1.4	1.5	Other	Total
Males						
Sample Size[a]	25	34	67	6	2	134
Percent	11.6	15.7	31.0	2.8	0.9	62.0
SE Percent	2.2	2.5	3.2	1.1	0.7	3.3
Mortality	42	57	113	10	3	225
SE Mortality	19	25	49	6	3	96
Females						
Sample Size[a]	2	4	73	3	0	82
Percent	0.9	1.9	33.8	1.4	0.0	38.0
SE Percent	0.7	0.9	3.2	0.8	0.0	3.3
Mortality	3	7	123	5	0	138
SE Mortality	3	4	53	3	0	59
Combined						
Sample Size[a]	27	38	140	9	2	216
Percent	12.5	17.6	64.8	4.2	0.9	100.0
SE Percent	2.3	2.6	3.3	1.4	0.7	
Mortality	45	64	236	15	3	363
SE Mortality	21	28	100	8	3	153

[a] Age/sex composition of released fish that died as a result of hook-and-release fishing was assumed equal to the age/sex composition of the inriver return during the stratum 7/01-7/23.

Table 7. Historical sonar counts of chinook salmon in the Kenai River during the late run, 1987-1993.

	1987		1988		1989		1990		1991		1992		1993	
Date	Daily Counts	Cum Counts	Daily Counts	Cum Counts	Daily Counts	Cum Counts	Daily Counts	Cum Counts	Daily Counts	Cum Counts	Daily Counts	Cum Counts	Daily Counts	Cum Counts
7/ 01	507	507	526	526	769	769	578	578	267	267	364	364	539	539
7/ 02	429	936	404	930	489	1,258	305	883	300	567	297	661	432	971
7/ 03	405	1,341	398	1,328	353	1,611	486	1,369	333	900	320	981	325	1,296
7/ 04	628	1,969	292	1,620	566	2,177	436	1,805	519	1,419	198	1,179	397	1,693
7/ 05	596	2,565	482	2,102	1,106	3,283	853	2,658	316	1,735	225	1,404	429	2,122
7/ 06	523	3,088	654	2,756	879	4,162	795	3,453	242	1,977	331	1,735	884	3,006
7/ 07	769	3,857	379	3,135	680	4,842	929	4,382	186	2,163	247	1,982	1,572	4,578
7/ 08	483	4,340	725	3,860	776	5,618	432	4,814	139	2,302	170	2,152	1,855	6,433
7/ 09	384	4,724	471	4,331	1,404	7,022	309	5,123	393	2,695	205	2,357	1,876	8,309
7/ 10	314	5,038	1,732	6,063	560	7,582	359	5,482	481	3,176	221	2,578	820	9,129
7/ 11	340	5,378	1,507	7,570	2,010	9,592	778	6,260	403	3,579	143	2,721	1,238	10,367
7/ 12	751	6,129	1,087	8,657	2,763	12,355	557	6,817	330	3,909	1,027	3,748	676	11,043
7/ 13	747	6,876	2,251	10,908	910	13,265	1,175	7,992	308	4,217	605	4,353	3,345	14,388
7/ 14	761	7,637	2,370	13,278	2,284	15,549	1,481	9,473	572	4,789	689	5,042	3,177	17,565
7/ 15	913	8,550	2,405	15,683	1,111	16,660	1,149	10,622	542	5,331	745	5,787	2,233	19,798
7/ 16	1,466	10,016	1,259	16,942	1,344	18,004	1,011	11,633	1,029	6,360	703	6,490	2,329	22,127
7/ 17	1,353	11,369	1,520	18,462	963	18,967	2,395	14,028	2,052	8,412	570	7,060	2,037	24,164
7/ 18	841	12,210	2,180	20,642	1,382	20,349	2,113	16,141	3,114	11,526	853	7,913	1,438	25,602
7/ 19	2,071	14,281	1,724	22,366	425	20,774	1,363	17,504	1,999	13,525	1,128	9,041	715	26,317
7/ 20	3,709	17,990	2,670	25,036	820	21,594	1,499	19,003	1,422	14,947	1,144	10,185	1,348	27,665
7/ 21	3,737	21,727	3,170	28,206	916	22,510	787	19,790	1,030	15,977	799	10,984	981	28,646
7/ 22	1,835	23,562	1,302	29,508	583	23,093	573	20,363	1,050	17,027	619	11,603	1,166	29,812
7/ 23	1,700	25,262	1,502	31,010	756	23,849	642	21,005	2,632	19,659	1,449	13,052	1,163	30,975
7/ 24	2,998	28,260	1,386	32,396	783	24,632	1,106	22,111	2,204	21,863	711	13,763	1,344	32,319
7/ 25	1,915	30,175	999	33,395	495	25,127	810	22,921	1,306	23,169	1,713	15,476	2,245	34,564
7/ 26	1,968	32,143	924	34,319	432	25,559	671	23,592	1,216	24,385	1,296	16,772	1,421	35,985
7/ 27	1,523	33,666	960	35,279	618	26,177	755	24,347	1,195	25,580	1,561	18,333	1,952	37,937
7/ 28	2,101	35,767	1,398	36,677	538	26,715	603	24,950	1,901	27,481	1,957	20,290	1,915	39,852
7/ 29	1,923	37,690	1,400	38,077	441	27,156	546	25,496	1,146	28,627	1,533	21,823	1,363	41,215
7/ 30	2,595	40,285	1,158	39,235	391	27,547	382	25,878	791	29,418	1,198	23,021	1,628	42,843
7/ 31	2,372	42,657	910	40,145	383	27,930	316	26,194	974	30,392	951	23,972	862	43,705
8/ 01	470	43,127	925	41,070	351	28,281	393	26,587	897	31,289	921	24,893	767	44,472
8/ 02	314	43,441	781	41,851	201	28,482	388	26,975	867	32,156	1,018	25,911	613	45,085
8/ 03	263	43,704	989	42,840	132	28,614	533	27,508	392	32,548	837	26,748	337	45,422
8/ 04	835	44,539	1,524	44,364	142	28,756	717	28,225	331	32,879	862	27,610	463	45,885
8/ 05	904	45,443	1,091	45,455	107	28,863	723	28,948	174	33,053	861	28,471	711	46,596
8/ 06	648	46,091	1,333	46,788	107	28,970	552	29,500	343	33,396	654	29,125	1,079	47,675
8/ 07	694	46,785	1,186	47,974	65	29,035	516	30,016	618	34,014	558	29,683	656	48,331
8/ 08	658	47,443	1,449	49,423			682	30,698	600	34,614	217	29,900	669	49,000
8/ 09	368	47,811	1,132	50,555			679	31,377			165	30,065	422	49,422
8/ 10	312	48,123	755	51,310			678	32,055			249	30,314	252	49,674
8/ 11		48,123	698	52,008			547	32,602						
8/ 12							362	32,964						
8/ 13							221	33,185						
8/ 14							139	33,324						
8/ 15							150	33,474						
Total		48,123		52,008		29,035		33,474		34,614		30,314		49,674

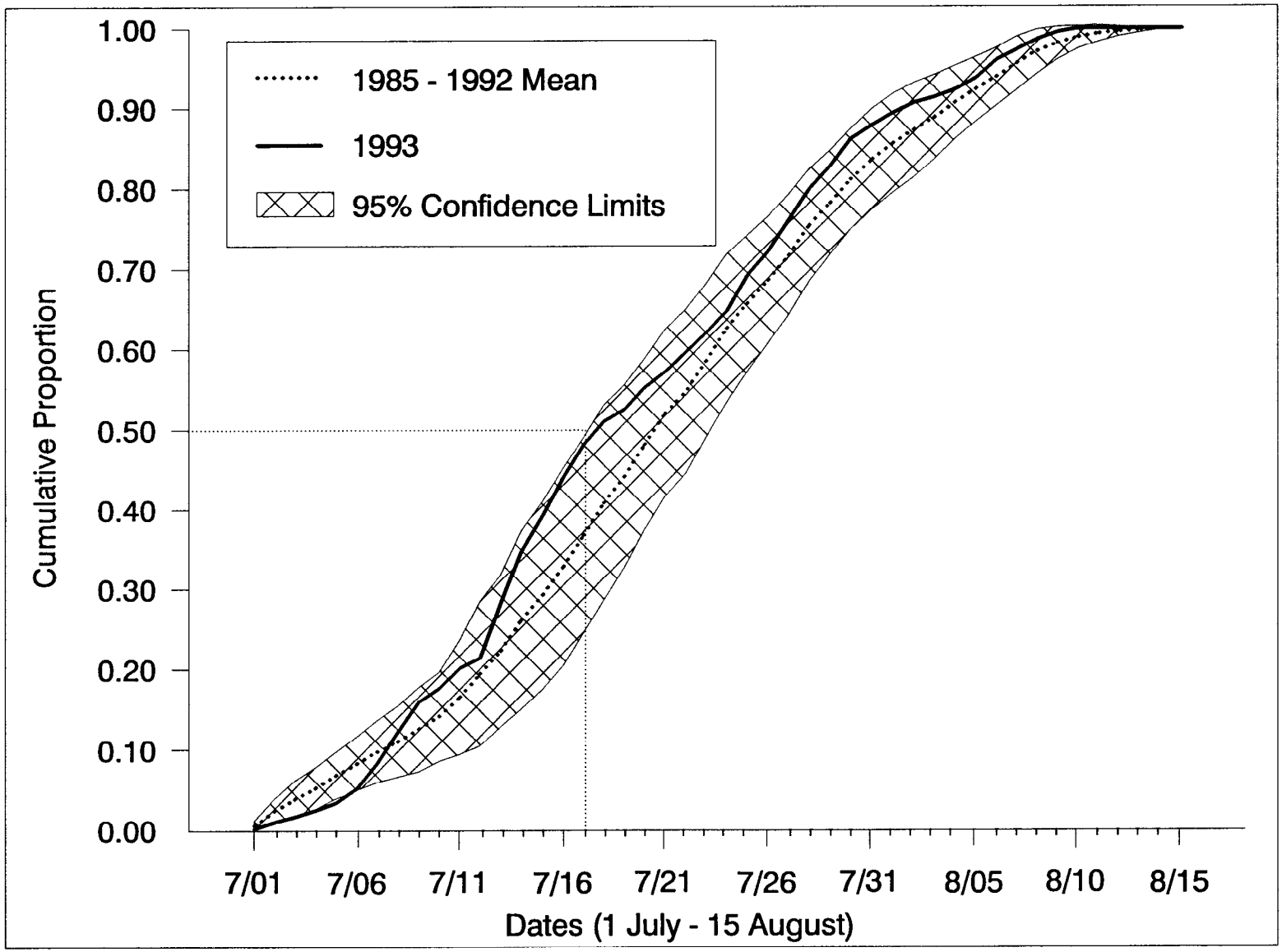

Figure 5. Cumulative proportions by date for the inriver return of late-run chinook salmon to the Kenai River, 1985-1992 mean vs. 1993.

Table 8. Estimates by age class of the number of late-run chinook salmon in the inriver return to the Kenai River, 1993.

	Age Class					
	1.2	1.3	1.4	1.5	2.3	Total
(7/01 - 7/23)						
Males						
Sample Size	25	34	67	6	2	134
Percent	11.6	15.7	31.0	2.8	0.9	62.0
SE Percent	2.2	2.5	3.2	1.1	0.7	3.3
Return	3,585	4,876	9,608	860	287	19,216
SE Return	676	769	977	347	202	1,025
Females						
Sample Size	2	4	73	3	0	82
Percent	0.9	1.9	33.8	1.4	0.0	38.0
SE Percent	0.7	0.9	3.2	0.8	0.0	3.3
Return	287	574	10,468	430	0	11,759
SE Return	202	285	999	247	0	1,025
Combined						
Sample Size	27	38	140	9	2	216
Percent	12.5	17.6	64.8	4.2	0.9	100.0
SE Percent	2.3	2.6	3.3	1.4	0.7	
Return	3,872	5,450	20,076	1,290	287	30,975
SE Return	699	804	1,009	422	202	
(7/24 - 8/15)						
Males						
Sample Size	1	9	45	6	0	61
Percent	0.7	6.7	33.6	4.5	0.0	45.5
SE Percent	0.7	2.2	4.1	1.8	0.0	4.3
Return	140	1,256	6,279	837	0	8,512
SE Return	140	406	766	335	0	807
Females						
Sample Size	0	2	66	5	0	73
Percent	0.0	1.5	49.3	3.7	0.0	54.5
SE Percent	0.0	1.1	4.3	1.6	0.0	4.3
Return	0	279	9,210	698	0	10,187
SE Return	0	197	811	307	0	807
Combined						
Sample Size	1	11	111	11	0	134
Percent	0.7	8.2	82.8	8.2	0.0	100.0
SE Percent	0.7	2.4	3.3	2.4	0.0	
Return	140	1,535	15,489	1,535	0	18,699
SE Return	140	445	611	445	0	
Late Run Total						
Males						
Percent	7.5	12.3	32.0	3.4	0.6	55.8
Return	3,725	6,132	15,887	1,697	287	27,728
SE Return	690	870	1,241	483	202	1,305
Females						
Percent	0.6	1.7	39.6	2.3	0.0	44.2
Return	287	853	19,678	1,128	0	21,946
SE Return	202	346	1,287	394	0	1,305
Combined						
Percent	8.1	14.1	71.6	5.7	0.6	100.0
Return	4,012	6,985	35,565	2,825	287	49,674
SE Return	712	919	1,180	613	202	

Table 9. Estimates by age class of the number of late-run chinook salmon in the total return to the Kenai River, 1986-1993.

	Age Class														
	0.2	0.3	0.4	0.5	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	Total
1986															
Percent	0.1	0.1	0.0	0.0	0.3	15.1	44.2	36.4	3.5	0.0	0.1	0.1	0.2	0.1	100.0
Return	43	43	22	22	260	12,017	35,314	29,039	2,774	22	43	43	152	43	79,837
SE Return	24	24	17	17	60	3,436	9,106	6,482	776	17	24	24	46	24	19,458
1987															
Percent	0	0	0	0	0.5	4.9	30.2	63.0	1.0	0.1	0.1	0.1	0.1	0.1	100.0
Return	0	0	0	0	361	3,635	22,427	46,812	775	99	51	44	97	58	74,359
SE Return					75	315	796	823	173	70	51	23	57	50	0
1988															
Percent	0	0	0.1	0	0.7	3.3	6.0	75.0	14.8	0	0	0.1	0.0	0.1	100.0
Return	0	0	35	0	454	2,235	4,116	51,233	10,121	0	0	46	15	101	68,356
SE Return			17		72	241	375	820	735			23	13	36	0
1989															
Percent	0	0	0	0	0.3	12.2	15.0	60.3	11.8	0.2	0.0	0.1	0	0.0	100.0
Return	0	0	0	0	108	5,053	6,194	24,908	4,888	76	0	34	0	13	41,274
SE Return					38	438	468	662	456	69		24		13	0
1990															
Percent	0	0.0	0.0	0	0.2	14.5	16.6	63.6	4.6	0	0.1	0.1	0.1	0.2	100.0
Return	0	11	11	0	65	5,749	6,572	25,237	1,841	0	45	23	23	79	39,656
SE Return		10	10		22	480	519	655	307		19	14	14	26	0
1991															
Percent	0.0	0	0.1	0	0.1	10.3	18.5	64.4	5.8	0	0.0	0	0.6	0.0	100.0
Return	15	0	31	0	46	4,291	7,687	26,732	2,396	0	15	0	261	15	41,489
SE Return	15		22		27	526	721	903	479		15		154	15	0
1992															
Percent	0	0	0	0	0.8	9.7	19.7	66.5	2.8	0	0	0.2	0.3	0.0	100.0
Return	0	0	0	0	347	4,311	8,746	29,515	1,230	0	0	82	123	19	44,373
SE Return					83	468	649	766	267			41	50	19	0
1993															
Percent	0	0	0	0	0.7	9.2	15.6	68.4	5.3	0	0	0.0	0.6	0.1	100.0
Return	0	0	0	0	440	5,951	10,097	44,201	3,428	0	0	16	385	65	64,583 [a]
SE Return					83	731	941	1,205	621			16	206	32	0

[a] Deep Creek marine recreational harvest is unaccounted for until harvest estimates are available in 1994.

Table 10. Estimates by age class of the number of late-run chinook salmon in the spawning escapement to the Kenai River, 1986-1993.

	Age Class									
	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.3	2.4	Total
1986										
Inriver Return	0	7,009	27,141	21,413	2,000	0	0	0	0	57,563
SE Return	0	3,428	9,101	6,474	769	0	0	0	0	19,457
Harvest	37	913	3,507	4,072	475	0	0	0	0	9,004
SE Harvest	26	131	266	289	94	0	0	0	0	458
H&R[a] Mortality	0	63	229	207	23	0	0	0	0	522
SE H&R	0	27	96	87	10	0	0	0	0	220
Escapement[b]	0	6,033	23,405	17,134	1,502	0	0	0	0	48,037
SE Escapement	0	3,431	9,105	6,481	775	0	0	0	0	19,464
1987										
Inriver Return	0	898	13,407	33,119	500	99	50	0	50	48,123
SE Return	0	209	696	719	157	70	50	0	50	0
Harvest	51	127	2,787	8,892	380	0	0	0	0	12,237
SE Harvest	36	57	292	611	99	0	0	0	0	769
H&R[a] Mortality	0	7	103	253	4	1	0	0	0	368
SE H&R	0	4	49	120	2	1	0	0	0	174
Escapement[b]	0	764	10,517	23,974	116	98	50	0	50	35,518
SE Escapement	0	217	756	951	186	70	50	0	50	788
1988										
Inriver Return	0	628	1,888	39,860	9,632	0	0	0	0	52,008
SE Return	0	198	340	793	732	0	0	0	0	0
Harvest	126	42	589	13,766	2,989	0	0	0	0	17,512
SE Harvest	73	42	159	887	368	0	0	0	0	1,036
H&R[a] Mortality	0	6	18	367	81	0	0	0	0	472
SE H&R	0	3	9	175	39	0	0	0	0	225
Escapement[b]	0	580	1,281	25,727	6,562	0	0	0	0	34,024
SE Escapement	0	202	375	1,203	820	0	0	0	0	1,060

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Table 10. (Page 2 of 3).

	Age Class									
	1.1	1.2	1.3	1.4	1.5	1.6	2.2	2.3	2.4	Total
1989										
Inriver Return	8	3,129	3,734	18,366	3,722	76	0	0	0	29,035
SE Return	8	409	437	629	440	69	0	0	0	0
Harvest	0	90	994	6,507	1,446	0	0	0	90	9,127
SE Harvest	0	90	291	585	345	0	0	0	90	582
H&R[a] Mortality	1	34	40	211	40	1	0	0	0	327
SE H&R	1	16	19	96	18	1	0	0	0	148
Escapement[b]	7	3,005	2,700	11,648	2,236	75	0	0	0	19,581
SE Escapement	8	419	525	864	559	69	0	0	90	601
1990										
Inriver Return	0	4,204	4,934	22,808	1,528	0	0	0	0	33,474
SE Return	0	471	510	647	304	0	0	0	0	0
Harvest	37	605	989	3,883	733	0	0	0	0	6,247
SE Harvest	26	109	142	322	121	0	0	0	0	445
H&R[a] Mortality	0	17	21	97	6	0	0	0	0	141
SE H&R	0	8	10	45	3	0	0	0	0	65
Escapement[b]	0	3,582	3,924	18,828	789	0	0	0	0	27,086
SE Escapement	0	484	529	724	327	0	0	0	0	450
1991										
Inriver Return	0	2,580	5,482	24,080	2,257	0	0	215	0	34,614
SE Return	0	507	705	889	477	0	0	152	0	0
Harvest	0	338	799	5,221	430	0	0	61	0	6,849
SE Harvest	0	101	155	369	114	0	0	43	0	410
H&R[a] Mortality	0	8	16	71	7	0	0	1	0	103
SE H&R	0	4	8	32	3	0	0	0	0	46
Escapement[b]	0	2,234	4,667	18,788	1,820	0	0	153	0	27,662
SE Escapement	0	517	722	963	490	0	0	158	0	413

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Table 10. (Page 3 of 3).

	Age Class									
	1.1	1.2	1.3	1.4	1.5	1.6	2.2	2.3	2.4	Total
1992										
Inriver Return	0	2,206	4,863	22,546	699	0	0	0	0	30,314
SE Return	0	427	603	718	247	0	0	0	0	0
Harvest	33	133	1,030	5,085	399	0	0	0	0	6,680
SE Harvest	33	66	185	405	115	0	0	0	0	462
H&R[a] Mortality	0	21	49	231	7	0	0	0	0	308
SE H&R	0	10	21	98	4	0	0	0	0	130
Escapement[b]	0	2,052	3,784	17,230	293	0	0	0	0	23,326
SE Escapement	0	432	631	830	272	0	0	0	0	480
1993										
Inriver Return	0	4,012	6,985	35,565	2,825	0	0	287	0	49,674
SE Return	0	712	919	1,180	613	0	0	202	0	0
Harvest	0	288	865	13,084	887	0	89	44	22	15,279
SE Harvest	0	80	139	569	141	0	44	31	22	620
H&R[a] Mortality	0	45	64	236	15	0	2	1	0	363
SE H&R	0	21	28	100	8	0	2	1	0	153
Escapement[b]	0	3,679	6,056	22,245	1,923	0	0	242	0	34,032
SE Escapement	0	717	930	1,314	629	0	44	204	22	639

[a] Hook and Release.

[b] For some age classes in some years the estimates of the number harvested in the sport fishery is greater than the estimate of the number in the inriver return. The spawning escapement for the age class was set to zero. When this occurred, the total spawning escapement (calculated by subtracting the total sport harvest plus the hook-and-release mortality from the inriver return) is not the sum of the escapement across age classes.

these spawners were age class 1.4. This age class has been the predominant spawning age class since 1986.

The total return of late-run chinook salmon to the Kenai River is the sum of the commercial, recreational, personal use and subsistence harvests plus the escapement (Table 11). The estimated total return of chinook salmon to the Kenai River in 1993 was 64,583.

Brood Relationships

Age components of measured returns are presented in Table 12 and a summary of the production from each brood year appears in Table 13. Total production from the first measured escapement (31,796 fish in 1984) barely exceeded replacement. Production from the 1985 escapement (21,708) was nearly a two-fold return. However, production from the largest measured escapement of 48,037 in 1986 appears only able to replace itself. Production from the 1987 escapement (35,318) is approaching that of 1985 at a 1.63 return-per spawner ratio with the age-7 (1.5) component to return in 1994.

Sibling Relationships

Sonnichsen and Alexandersdottir (1991) used sibling return ratios to forecast future returns (Table 14). Total return for the 1990 late run was forecast at 33,517 fish; the observed value was 39,656 or 18% greater than the expected value (Table 15). Using similar techniques, but including values observed in 1990, they predicted a return of 43,487 for 1991. The observed value was 41,849, 4.6% less than the forecast value. A return of 42,949 was forecast for 1992 (Hammarstrom 1992); the observed return was 44,373, 3.3% greater than the forecast value. The 1993 forecast was 49,696 (Hammarstrom 1993). The observed return of 64,583 was 30% greater than anticipated.

Incorporating the observed 1993 values into the sibling ratio equations results in an expected return in 1994 of 66,876 chinook salmon to the Kenai River during the late run (Table 15).

Sonnichsen and Alexandersdottir (1991) also examined the relationship between different levels of returns at age 5 and subsequent returns at age 6 (Figure 6). These two age groups contain the majority of chinook salmon returning to the Kenai River. Their analysis suggested that at lower abundance levels, the ratio of age 6 to age 5 is greater. From the 1981 and 1982 brood year, fish that returned as age 5 numbered 35,379 and 22,471, respectively. The following year's age 6 returned at a ratio of 1.3 and 2.3, respectively. For the brood years 1983-1987, age 6 returned at ratios of 5.9, 4.1, 4.1, 3.8, and 5.1, respectively. These ratios occurred at levels of age-5 fish of 4,197, 6,228, 6,606, 7,718, and 8,828 respectively (Figure 6). The return of age 5 from the 1988 brood was 10,113. If the assumption of a greater return ratio occurring at lower abundance levels holds true, the forecasted return of age 6 in 1994 is 46,459 (SE = 10,707) (using the mean age 5 to age 6 ratio from brood years 1983-1987). This is 24% more age-6 fish than predicted by the sibling relationship. The relationship between age 5 and age 6 came closer to predicting the return of age-6 fish in the 1993 return than did the sibling model by approximately 10,000 fish.

Table 11. Summary of late-run Kenai River chinook salmon population data, 1984-1993.

Year	Deep Creek Marine Harvest	Eastside Set Net Harvest	Drift Gill Net Harvest	Commercial Personal Use	Subsistence [a]	Inriver Return	Total Return	Kenai River		Escapement
								Sport Harvest	Hook-and-Release Mortality	
1984	835	6,165	1,377			39,172	47,549	7,376	Unknown	31,796
1985	1,731	17,723	2,046			29,763	51,263	8,055	Unknown	21,708
1986	630	19,810	1,834			57,563	79,837	9,004	522	48,037
1987	1,097	20,588	4,551			48,123	74,359	12,237	368	35,518
1988	1,262	12,870	2,216			52,008	68,356	17,512	472	34,024
1989	1,294	10,919	0 [b]	4	22	29,035	41,274	9,127	327	19,581
1990	1,318	4,139	621	91	13	33,474	39,656	6,247	141	27,086
1991	1,325	4,891	241	130	288	34,614	41,489	6,849	103	27,662
1992	2,346	10,718	543	50	402 [c]	30,314	44,373	6,680	308	23,326
1993	Unknown	14,002	751	129	27 [d]	49,674	64,583 [e]	15,279	363	34,032

[a] Includes harvest in Kenaitze educational gill net fishery.

[b] Drift gill net fishery closed due to Exxon Valdez oil spill.

[c] Includes 10 fish harvested in the Kenaitze educational fishery, 260 fish harvested in the subsistence set net fishery and 132 fish harvested in the subsistence dip net fishery.

[d] Only Kenaitze educational fishery open to subsistence fishing.

[e] Total return data are incomplete until the estimated Deep Creek Marine Harvest becomes available.

Table 12. Age components of total returns of Kenai River late-run chinook salmon, 1986-1993.

Year	(0.2, 1.1) Age 3	(0.3, 1.2, 2.1) Age 4	(0.4, 1.3, 2.2) Age 5	(0.5, 1.4, 2.3) Age 6	(1.5, 2.4) Age 7	(1.6, 2.5) Age 8	Total Return
1986	303	12,103	35,379	29,213	2,817	22	79,837
1987	361	3,686	22,471	46,909	833	99	74,359
1988	454	2,235	4,197	51,249	10,221		68,356
1989	108	5,053	6,228	24,908	4,901	76	41,274
1990	65	5,805	6,606	25,260	1,920		39,656
1991	61	4,306	7,718	26,993	2,411		41,489
1992	347	4,311	8,828	29,638	1,249		44,373
1993	440	5,951	10,113	44,586	3,493		64,583 [a]

[a] Deep Creek marine recreational harvest is unaccounted for until harvest estimates are available in 1994.

Table 13. Summary of returns from each brood year, late-run Kenai River chinook salmon, 1978-1993.

Year	Spawning Escapement	RETURN (0.2,1.1) Age	(0.3,1.2,2.1) Age	(0.4,1.3,2.2) Age	(0.5,1.4,2.3) Age	(1.5,2.4) Age	(1.6,2.5) Age	Total Return To Date	Return Per Spawner
1978	Unknown						(1986) 22	22	
1979	Unknown					(1986) 2,817	(1987) 99	2,916	
1980	Unknown				(1986) 29,213	(1987) 833		30,046	
1981	Unknown			(1986) 35,379	(1987) 46,909	(1988) 10,221	(1989) 76	92,585	
1982	Unknown		(1986) 12,103	(1987) 22,471	(1988) 51,249	(1989) 4,901		90,724	
1983	Unknown	(1986) 303	(1987) 3,686	(1988) 4,197	(1989) 24,908	(1990) 1,920		35,014	
1984	31,796	(1987) 361	(1988) 2,235	(1989) 6,228	(1990) 25,260	(1991) 2,411		36,495	1.15
1985	21,708	(1988) 454	(1989) 5,053	(1990) 6,606	(1991) 26,993	(1992) 1,249		40,355	1.86
1986	48,037	(1989) 108	(1990) 5,805	(1991) 7,718	(1992) 29,638	(1993) 3,493		46,762 [a]	0.97
1987	35,518	(1990) 65	(1991) 4,306	(1992) 8,828	(1993) 44,586			57,785 [a]	1.63
1988	34,024	(1991) 61	(1992) 4,311	(1993) 10,113				14,485 [a]	0.43
1989	19,581	(1992) 347	(1993) 5,951					6,298 [a]	0.32
1990	27,086	(1993) 440						440 [a]	
1991	27,662								
1992	23,326								
1993	34,032								

[a] 1993 Deep Creek marine recreational harvest unaccounted for until harvest estimates are available in 1994.

Table 14. Sibling return ratios[a] for late-run Kenai River chinook salmon from brood years 1980-1989.

Brood Year	Age 4/ Age 3	Age 5/ Age 4	Age 6/ Age 5	Age 6/ Age 4+5	Age 7/ Age 6	Age 7/ Age 5+6	Age 7/ Age 4+5+6
1980					0.03		
1981			1.33		0.22	0.12	
1982		1.86	2.28	1.48	0.10	0.07	0.06
1983	12.17	1.14	5.93	3.16	0.08	0.07	0.06
1984	6.19	2.79	4.06	2.98	0.10	0.08	0.07
1985	11.13	1.31	4.09	2.32	0.05	0.04	0.03
1986	53.75	1.33	3.84	2.19	0.12	0.09	0.08
1987	66.25	2.05	5.05	3.39			
1988	70.67	2.35					
1989	17.15						
Mean	33.90	1.83	3.80	2.59	0.10	0.08	0.06
Std. Dev.	28.38	0.61	1.57	0.72	0.06	0.03	0.02
% Coeff. Var.	84	33	41	28	63	37	32
Maximum	70.67	2.79	5.93	3.39	0.22	0.12	0.08
Minimum	6.19	1.14	1.33	1.48	0.03	0.04	0.03

[a] 1993 Deep Creek marine recreational harvest is unaccounted for until harvest estimates are available in 1994.

Table 15. Summary of expected returns based on sibling ratios versus observed returns, late-run Kenai River chinook salmon, 1990-1993, and 1994 projections.

	RETURN					
	Age 3	Age 4	Age 5	Age 6	Age 7	Total
1990						
Expected	306	1,061	9,736	19,639	2,775	33,517
Observed	65	5,806	6,606	25,259	1,920	39,656
Difference	(241)	4,745	(3,130)	5,620	(855)	6,139
Obs. as % of Exp.	21.2	547.2	67.9	128.6	69.2	118.3
1991						
Expected	258	1,353	10,289	29,637	1,950	43,487
Observed	61	4,306	7,718	26,993	2,411	41,489
Difference	(197)	2,953	(2,571)	(2,644)	461	(1,998)
Obs. as % of Exp.	23.6	318.3	75.0	91.1	123.6	95.4
1992						
Expected	223	1,328	6,634	32,397	2,367	42,949
Observed	347	4,311	8,828	29,638	1,249	44,373
Difference	124	2,983	2,194	(2,759)	(1,118)	1,424
Obs. as % of Exp.	155.6	324.6	133.1	91.5	52.8	103.3
1993						
Projected	234	10,327	6,808	30,048	2,279	49,696
Observed	440	5,951	10,113	44,586	3,493	64,583
Difference	206	(4,376)	3,305	14,538	1,214	14,887
Obs. as % of Exp.	188.0	57.6	148.5	148.4	153.3	130.0
1994						
Projected	267	14,916	10,894	37,331	3,468	66,876
Standard Error	58	14,838	4,264	11,041	1,239	19,021

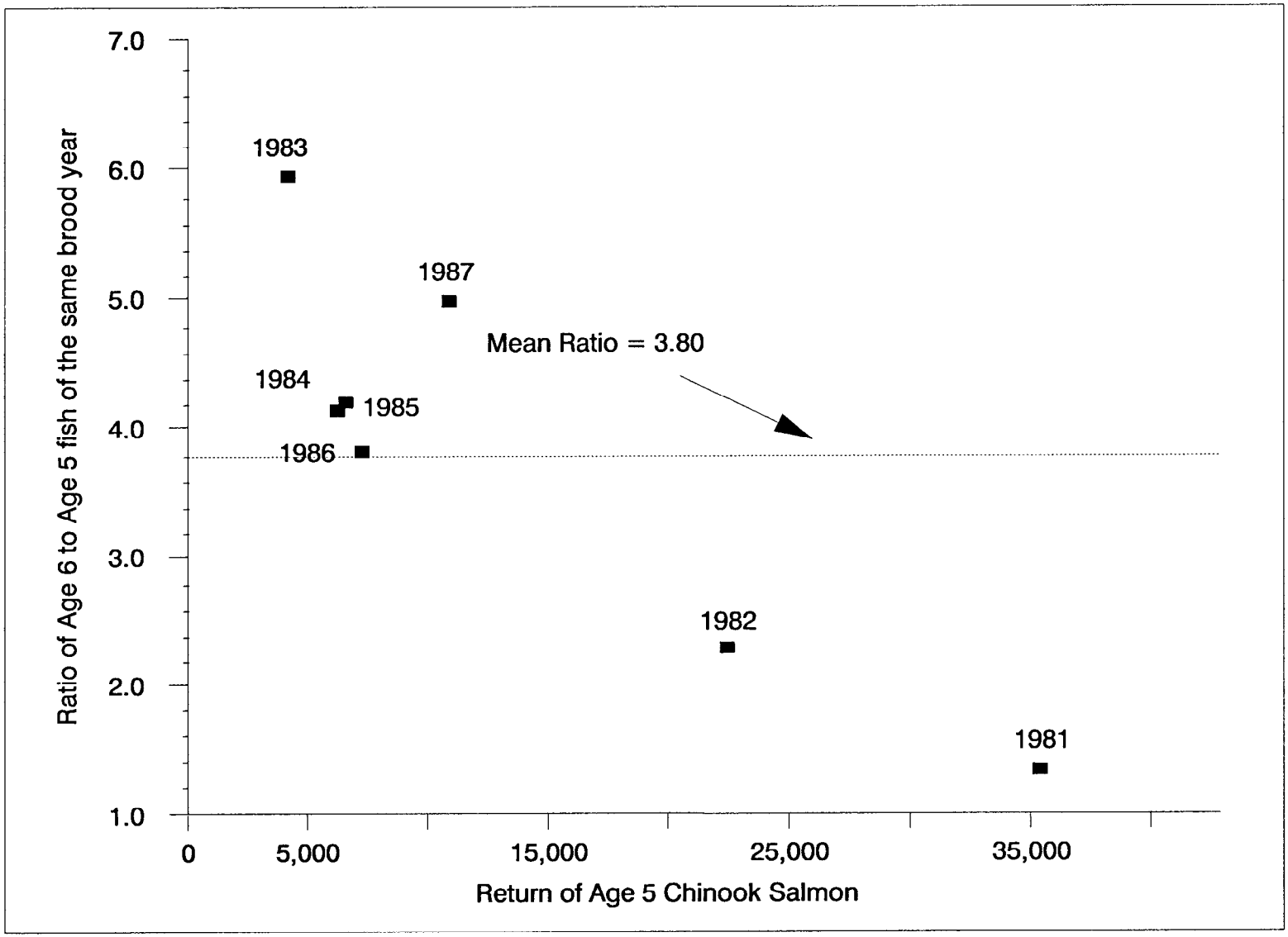

Figure 6. Ratio of the return of age-6 adults to age-5 adults compared to the numbers of age-5 adult late-run chinook salmon returning to the Kenai River, brood years 1981-1987.

A regression analysis was conducted to determine if the return of age-5 chinook salmon had a linear relationship with the return of age-6 chinook salmon the following year. Although the model was significant ($t = 2.75$, $df = 5$, $P = 0.04$, $b_1 = 0.769$, $SE(b_1) = 0.280$, $R^2 = 0.52$), a plot of the data indicated that two brood years, 1981 and 1982, likely caused this result (Figure 7). Excluding these 2 years, years of unknown escapement that produced total returns far in excess of that observed in later years resulted in no significant linear relationship ($t = 2.35$, $df = 3$, $P = 0.10$, $b_1 = 3.81$, $SE(b_1) = 1.62$, $R^2 = 0.53$). This result indicates that the average return of age-6 chinook salmon is the best predictor when the return of age-5 chinook salmon is below approximately 10,000 fish. Currently, there are not sufficient data, and the data appear too clumped, to detect a linear relationship between the return of age-6 chinook salmon and the return of age-5 chinook salmon the previous year.

Migratory Timing Models

The neap tide model performed poorly in 1993, consistently underestimating the total return (Figure 8). This model had predicted that 50% of the run would have entered the river by 14 July. Daily sonar counts began to increase rapidly on 6 July with the first 1,000+ fish day occurring on 7 July (Table 7). The only other year that had a 1,000+ fish day this early was 1989, the same year that had a similar neap tide date. By 13 July, the cumulative count of late-run chinook salmon into the Kenai River had exceeded every other year's cumulative count for that date. As of 14 July, 17,565 chinook salmon had been enumerated, suggesting an inriver return of approximately 35,000 fish. One week later (21 July), the cumulative count was nearly 29,000 with daily counts exceeding 1,000 fish. The projected escapement with no changes to the recreational fishery was 23,600. Confidence in the neap tide model began to fade and it was felt the run was relatively strong and no restrictions would be necessary to achieve the escapement goal. By 25 July, nearly 35,000 fish had entered the river and another 10,000 chinook salmon had been harvested in the commercial fishery. By the end of July, it was apparent that the escapement goal of 22,300 would be achieved and that sufficient surplus fish would be available to allow additional fishing in that area of the river downstream of any known spawning. An emergency order extending chinook salmon fishing downstream of "Eagle Rock" (rkm 18.5) through 4 August was announced 28 July. Although the neap tide model continues to predict the peak date of fish passage, it has not performed nearly as well in predicting the total return.

The curve-fit model did not perform well in 1993. It consistently overestimated the total return throughout the season (Figure 8).

The mean timing model performed best of the three in 1993 (Figure 8). Daily estimates of the return were underestimated early in the run, slightly overestimated during mid-July, but by 20 July were within 10% of the realized return.

The return model based on commercial harvest also performed well in 1993. This model has performed well in the past but fishing time in this fishery is reflective of the size of the sockeye salmon return. The chinook salmon harvest is merely bycatch. Although the harvest of chinook salmon by the set gill net fishery along the eastern shore of Cook Inlet does not appear to

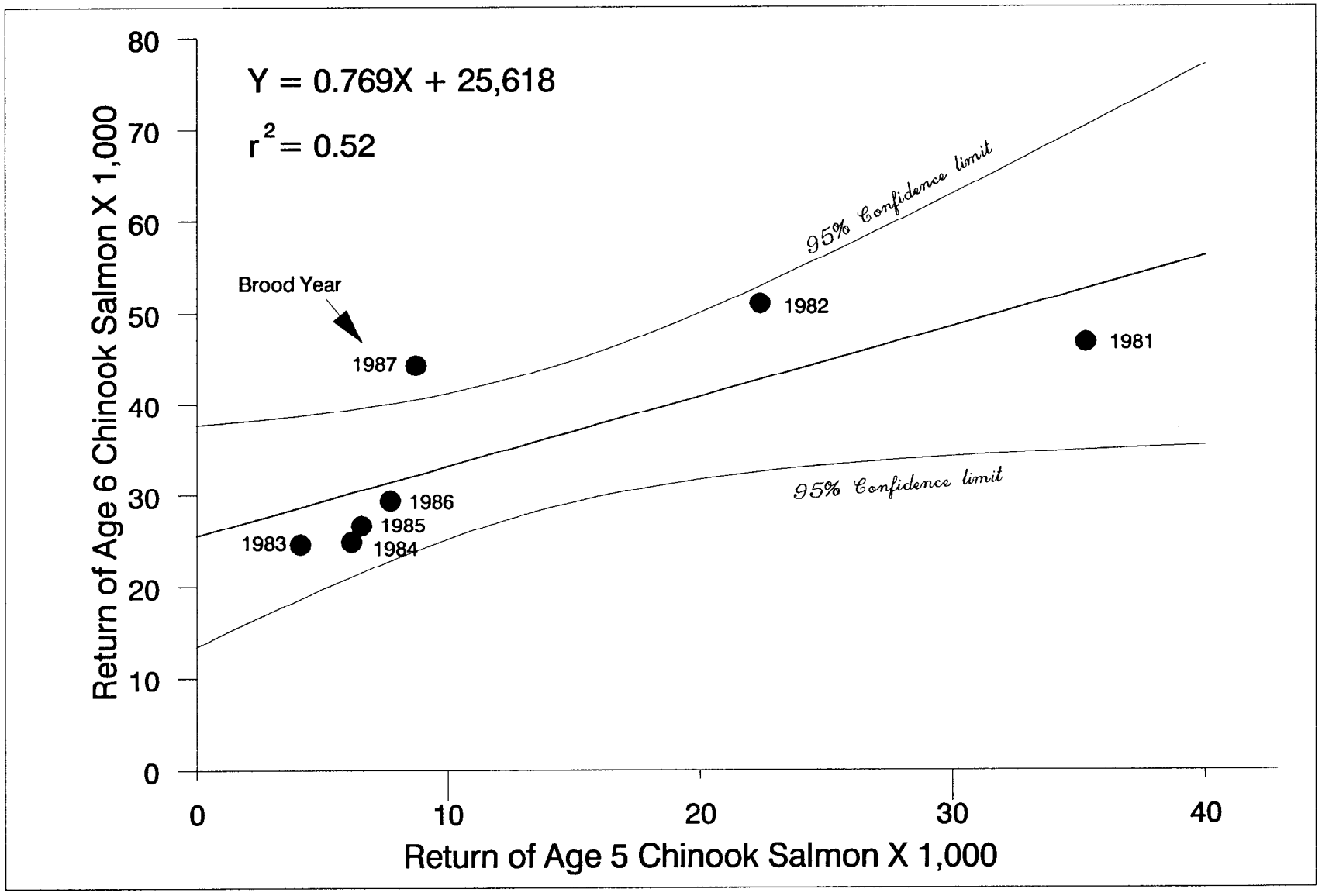

Figure 7. Regression analysis of the return of age-6 Kenai River chinook salmon as a function of the return of age-5 chinook salmon the previous year.

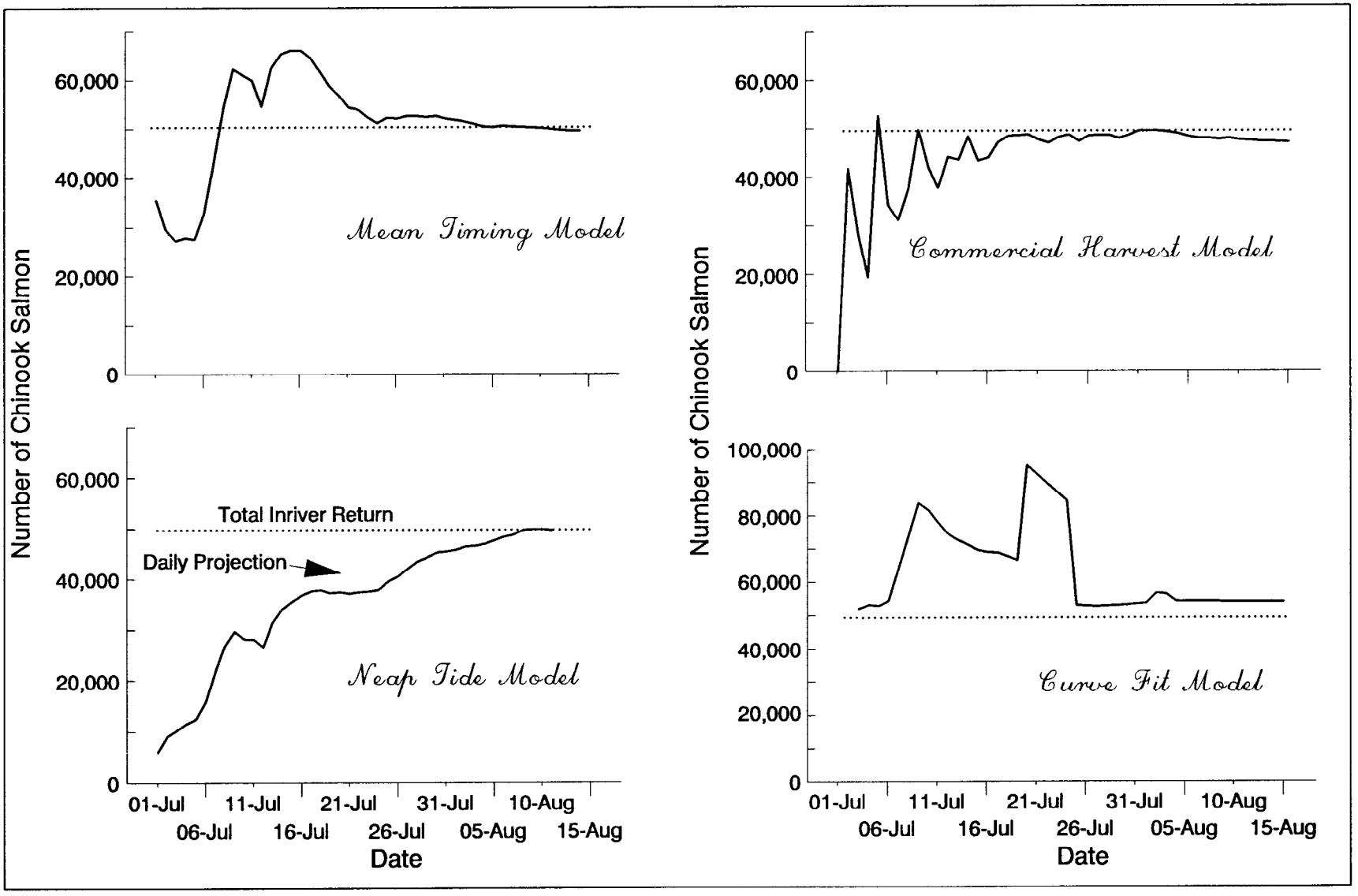

Figure 8. Daily projections of end-of-season inriver return vs. the actual inriver return of late-run chinook salmon, Kenai River, 1993, comparing four run timing models.

represent a linear relationship with fishing time, it is fair to assume that harvest, and therefore exploitation rate, will fluctuate to some degree with allowable fishing time. For this reason, this model is not the model of choice.

Of the four models evaluated to predict inriver return, none have performed well consistently. Therefore, the models were compared further in order to recommend a model for the 1994 season. The analysis was limited to 15 July through 25 July, when decisions to modify the recreational or commercial fishery in order to achieve the escapement goal are most likely. Because of variability in timing early in the run, modifying the fisheries prior to 15 July would be difficult to justify. After 25 July, most of the return has already passed through the commercial fishery, and only a few days of recreational fishing remain (the season closes 31 July) during which any management action would be effective.

A projection was calculated for each day from 15 July through 25 July using each model for the years 1987-1993 (Appendix C). The data base contained data from all years except the year for which the projection was being made. Each daily projection was then subtracted from the end-of-season inriver return for that year and the difference squared. The squared differences were then averaged for the period covered (i.e. 15 July-25 July or 20 July-25 July), and ranked accordingly with the lowest value having the best ranking (Table 16).

DISCUSSION

Based on comparisons of the four run timing models, I recommend that the mean timing model be used in 1994. Its performance ranking was second during the period 15 July-25 July and first during the period 20 July-25 July. With an anticipated return of approximately 67,000 in 1994, management action prior to 20 July is unlikely.

The results of the sibling model to predict future returns have been encouraging and evaluation should continue. Evaluation of the linear regression model should also continue, because it may prove to be a more precise predictor. Therefore, I recommend that the sibling model be used for 1994 and reevaluated since the anticipated return of age-5 fish in 1994 is nearly 11,000. If these techniques continue to perform well, inseason management should become more predictable.

Information concerning the behavior of migrating chinook salmon in the Kenai River has been gained through telemetry (T. Bendock, Alaska Department of Fish and Game, Soldotna, personal communication), suggesting that the confluence areas around the mouths of Slikok Creek and Funny River are important staging areas for chinook salmon. Recommendations to restrict fishing in these immediate areas were made to the Board of Fisheries to be considered at their November 1992 meeting. The BOF adopted regulations closing these areas to chinook salmon fishing through 14 July. Although the regulations are designed to protect early-run fish, they are in effect while late-run fish are also susceptible to harvest in these areas.

One source of bias in the age composition of the inriver return may be the selectivity of the test gill nets against precocial males (age 1.1).

Table 16. Summary of performance of four run timing models used to predict the inriver return of late-run chinook salmon to the Kenai River, 1987-1993.

	Mean Sum of Squares[a]			
	MEAN TIMING MODEL	NEAP TIDE MODEL	CURVE FIT MODEL	COMMERCIAL HARVEST MODEL
	Time Period: 15 July - 25 July			
1987	217,830,951	81,395,311	35,896,511	23,944,701
1988	6,502,456	1,588,264,554	583,717,373	111,276,357
1989	411,471,720	3,237,169	2,588,801,316	17,330,996
1990	12,300,817	6,264,079	537,161,403	535,275,765
1991	90,691,732	21,363,252	10,784,341	201,127,970
1992	119,380,164	115,790,474	51,256,560	6,664,584
1993	101,672,377	148,171,470	902,569,403	6,281,352
Mean	137,121,459	280,640,901	672,883,844	128,843,103
Mean Rank	2	3	4	1
	Time Period: 20 July - 25 July			
1987	54,785,475	22,628,506	42,336,329	42,518,055
1988	1,596,312	593,163,606	565,703,131	135,244,642
1989	200,169,539	1,519,143	1,917,945,892	21,003,795
1990	11,600,036	6,328,809	512,482,409	439,379,996
1991	11,835,217	10,552,782	8,628,996	231,124,976
1992	91,697,786	31,602,838	89,004,063	8,072,018
1993	18,983,134	139,354,734	1,359,607,076	4,159,327
Mean	55,809,643	115,021,488	642,243,985	125,928,973
Mean Rank	1	2	4	3
	Rank of Mean Sum of Squares			
	Time Period: 15 July - 25 July			
1987	4	3	2	1
1988	1	4	3	2
1989	3	1	4	2
1990	2	1	4	3
1991	3	2	1	4
1992	4	3	2	1
1993	2	3	4	1
	Time Period: 20 July - 25 July			
1987	4	1	2	3
1988	1	4	3	2
1989	3	1	4	2
1990	2	1	4	3
1991	3	2	1	4
1992	4	2	3	1
1993	2	3	4	1

[a] Average of the daily differences squared of the projected inriver return less the realized inriver return.

Representatives of this age class appear in the commercial gill net harvest to a larger extent than in either the recreational fishery or the gill nets used to sample the inriver return. Additionally, fish of this age class are not enumerated by the existing sonar gear. Thus, estimates of this age class are probably biased low, but I do not believe fish of this age class account for a significant portion of the population.

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APPENDIX A

Kenai River Late King Salmon Management Plan

Appendix A. Kenai River Late King Salmon Management Plan.

5 AAC 21.359 KENAI RIVER LATE KING SALMON MANAGEMENT PLAN.

(a) The purpose of this management plan is to insure an adequate escapement of late run chinook salmon into the Kenai River system and to provide management guidelines to the department.

(b) The department shall manage the late run Kenai River chinook salmon to achieve a minimum spawning escapement level of 15,500 salmon and an optimum spawning escapement level of 22,300 salmon as follows:

(1) if the projected spawning escapement level is less than 15,500, the department shall

(A) close the recreational fisheries in the Kenai River and in the salt waters of Cook Inlet north of the latitude of Bluff Point to the taking of chinook salmon;

(B) close the drift gill net fishery in the Central District within 3 miles of the Kenai Peninsula shoreline; and

(C) close the set gill net fishery in the Upper Subdistrict of the Central District;

(2) if the projected spawning escapement level is between 15,500 and 22,300 chinook salmon, the department shall restrict the taking of chinook salmon in the Kenai River recreational fisheries as necessary to achieve the optimum escapement; the department shall establish periods by emergency order during which

(A) time or area is reduced;

(B) bag or possession limits are zero; when the sport fishery is restricted to catch and release only, king salmon 52 inches or more in length may be retained; or

Note: changed from "(B) bag or possession limits are zero; or" in 1990

(C) only artificial lures may be used.

Note: The following sections modified the original plan above and were adopted at the December 1990 meeting of the Board of Fisheries.

(3) if the projected spawning escapement of chinook salmon is between 15,500 and 19,900, the department shall restrict the commercial fisheries as follows;

(A) within three miles of the Kenai Peninsula shoreline, the department shall limit the drift gill net fishery to regular periods;

-continued-

(B) the department shall limit the set gill net fishery in the Upper Subdistrict of the Central District to regular periods;

(c) however, if the final inriver sonar count is projected to exceed 700,000 sockeye salmon, then the drift gill net fishery and the set gill net fishery will not be restricted to conserve Kenai River chinook salmon unless the projected spawning escapement is less than 15,500, consistent with (b)(1).

(d) consistent with the purpose of this management plan, the department shall not reduce closed waters at the mouth of the Kenai River when the projected escapement level is less than 22,300 chinook salmon.

(e) the Kasilof River Sockeye Salmon Special Harvest Area Management Plan (5 AAC 21.356) is exempt from all provisions of this management plan.

Effective 1989, modified 1991.

APPENDIX B

Supporting statistics used to prepare the migratory timing model for the return of late-run chinook salmon to the Kenai River and used inseason to project the inriver return and associated harvest in the recreational fishery, 1993.

Appendix B1. Historical daily cumulative proportions of the inriver return of late-run chinook salmon to the Kenai River, 1985-1993.

	Daily cumulative proportions [P(t)] by year of inriver return											95% Confidence Interval		
Date	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean	SE	Low	High	Rel[a] Prec
7/01	0.025	0.014	0.012	0.012	0.036	0.016	0.008	0.012	0.011	0.017	0.003	0.009	0.024	45.2%
7/02	0.049	0.070	0.028	0.031	0.072	0.025	0.016	0.022	0.020	0.039	0.008	0.021	0.057	46.4%
7/03	0.080	0.095	0.040	0.063	0.088	0.038	0.026	0.032	0.026	0.058	0.010	0.035	0.081	39.4%
7/04	0.099	0.111	0.040	0.076	0.120	0.050	0.041	0.039	0.034	0.072	0.012	0.043	0.100	39.6%
7/05	0.120	0.116	0.067	0.101	0.158	0.075	0.050	0.046	0.043	0.092	0.014	0.059	0.124	35.4%
7/06	0.138	0.122	0.086	0.117	0.198	0.096	0.057	0.057	0.061	0.109	0.016	0.070	0.148	35.6%
7/07	0.170	0.127	0.104	0.148	0.235	0.117	0.062	0.065	0.092	0.129	0.020	0.081	0.176	36.9%
7/08	0.190	0.131	0.117	0.176	0.267	0.129	0.066	0.071	0.130	0.143	0.023	0.088	0.199	38.6%
7/09	0.206	0.142	0.127	0.210	0.326	0.139	0.077	0.078	0.167	0.163	0.029	0.094	0.232	42.2%
7/10	0.232	0.154	0.139	0.243	0.386	0.150	0.091	0.085	0.184	0.185	0.035	0.102	0.268	44.9%
7/11	0.264	0.166	0.150	0.265	0.435	0.171	0.103	0.090	0.209	0.206	0.040	0.111	0.300	46.0%
7/12	0.292	0.181	0.163	0.301	0.498	0.188	0.112	0.124	0.222	0.232	0.045	0.125	0.339	46.0%
7/13	0.325	0.219	0.185	0.337	0.531	0.223	0.121	0.144	0.290	0.261	0.047	0.149	0.372	42.9%
7/14	0.376	0.250	0.204	0.362	0.603	0.267	0.138	0.166	0.354	0.296	0.053	0.170	0.421	42.5%
7/15	0.414	0.283	0.220	0.395	0.631	0.301	0.153	0.191	0.399	0.324	0.055	0.194	0.453	40.0%
7/16	0.458	0.333	0.249	0.446	0.662	0.332	0.183	0.214	0.445	0.360	0.056	0.227	0.492	36.8%
7/17	0.485	0.377	0.298	0.474	0.694	0.405	0.241	0.233	0.486	0.401	0.054	0.273	0.528	31.9%
7/18	0.495	0.397	0.328	0.498	0.727	0.469	0.331	0.261	0.515	0.438	0.051	0.317	0.560	27.7%
7/19	0.510	0.421	0.355	0.534	0.743	0.510	0.390	0.298	0.530	0.470	0.049	0.355	0.586	24.5%
7/20	0.523	0.441	0.386	0.555	0.766	0.556	0.433	0.336	0.557	0.500	0.047	0.388	0.611	22.4%
7/21	0.565	0.466	0.429	0.583	0.793	0.580	0.464	0.362	0.577	0.530	0.047	0.420	0.641	20.9%
7/22	0.596	0.490	0.469	0.620	0.811	0.596	0.494	0.383	0.600	0.557	0.046	0.449	0.666	19.5%
7/23	0.627	0.527	0.499	0.649	0.835	0.616	0.571	0.431	0.624	0.594	0.043	0.493	0.696	17.1%
7/24	0.656	0.589	0.533	0.673	0.847	0.650	0.635	0.454	0.651	0.630	0.041	0.534	0.725	15.2%
7/25	0.692	0.603	0.578	0.696	0.864	0.675	0.672	0.511	0.696	0.661	0.037	0.574	0.749	13.2%
7/26	0.723	0.629	0.616	0.717	0.883	0.695	0.708	0.553	0.724	0.690	0.035	0.608	0.772	11.9%
7/27	0.767	0.654	0.648	0.739	0.899	0.718	0.742	0.605	0.764	0.721	0.032	0.645	0.798	10.6%
7/28	0.808	0.678	0.686	0.756	0.911	0.737	0.797	0.669	0.802	0.755	0.029	0.687	0.824	9.1%
7/29	0.825	0.700	0.711	0.769	0.924	0.754	0.830	0.720	0.830	0.779	0.027	0.715	0.843	8.2%
7/30	0.865	0.728	0.751	0.783	0.937	0.766	0.852	0.759	0.862	0.805	0.025	0.745	0.865	7.5%
7/31	0.885	0.754	0.801	0.814	0.948	0.776	0.880	0.791	0.880	0.831	0.023	0.776	0.886	6.7%
8/01	0.909	0.778	0.841	0.850	0.966	0.788	0.906	0.821	0.895	0.857	0.023	0.803	0.911	6.3%
8/02	0.920	0.799	0.841	0.887	0.973	0.800	0.930	0.855	0.908	0.875	0.022	0.823	0.928	6.0%
8/03	0.929	0.829	0.864	0.917	0.977	0.816	0.941	0.882	0.914	0.895	0.020	0.847	0.942	5.3%
8/04	0.939	0.855	0.891	0.941	0.986	0.838	0.950	0.911	0.924	0.914	0.018	0.872	0.956	4.6%
8/05	0.952	0.874	0.913	0.968	0.986	0.860	0.955	0.939	0.938	0.931	0.016	0.893	0.968	4.0%
8/06	0.962	0.895	0.924	0.987	0.986	0.877	0.965	0.961	0.960	0.945	0.015	0.910	0.979	3.7%
8/07	0.984	0.917	0.945	1.000	1.000	0.893	0.983	0.979	0.973	0.963	0.014	0.929	0.996	3.5%
8/08	0.997	0.935	0.965	1.000	1.000	0.915	1.000	0.986	0.986	0.975	0.012	0.947	1.003	2.9%
8/09	1.000	0.956	0.977	1.000	1.000	0.936	1.000	0.992	0.995	0.983	0.009	0.962	1.003	2.1%
8/10	1.000	0.968	0.989	1.000	1.000	0.957	1.000	1.000	1.000	0.989	0.006	0.975	1.004	1.5%
8/11	1.000	0.975	1.000	1.000	1.000	0.974	1.000	1.000	1.000	0.994	0.004	0.984	1.004	1.0%
8/12	1.000	0.984	1.000	1.000	1.000	0.985	1.000	1.000	1.000	0.996	0.003	0.990	1.002	0.6%
8/13	1.000	0.992	1.000	1.000	1.000	0.992	1.000	1.000	1.000	0.998	0.001	0.995	1.001	0.3%
8/14	1.000	1.000	1.000	1.000	1.000	0.996	1.000	1.000	1.000	1.000	0.000	0.998	1.001	0.1%
8/15	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.0%

[a] Relative precision.

Appendix B2. Historical daily cumulative proportions of the effort by unguided anglers during the return of late-run chinook salmon to the Kenai River, 1984-1993.

	Daily cumulative proportions [P(t)] by year of unguided angler effort												95% Confidence Interval		
Date	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean	SE	Low	High	Rel[a] Prec
7/01	0.009	0.005	0.015	0.004	0.018	0.032	0.051	0.000	0.030	0.012	0.017	0.006	0.003	0.030	82.4%
7/02	0.022	0.011	0.026	0.016	0.044	0.070	0.051	0.022	0.052	0.027	0.033	0.007	0.017	0.049	49.4%
7/03	0.040	0.013	0.046	0.053	0.069	0.070	0.091	0.036	0.087	0.056	0.052	0.009	0.033	0.072	36.9%
7/04	0.063	0.024	0.069	0.090	0.069	0.101	0.109	0.059	0.127	0.090	0.073	0.010	0.052	0.095	29.4%
7/05	0.092	0.046	0.112	0.142	0.089	0.129	0.138	0.084	0.155	0.090	0.104	0.012	0.078	0.130	25.1%
7/06	0.108	0.084	0.124	0.142	0.102	0.151	0.169	0.118	0.155	0.112	0.125	0.010	0.102	0.147	18.0%
7/07	0.163	0.102	0.124	0.162	0.123	0.181	0.209	0.141	0.170	0.134	0.151	0.012	0.123	0.179	18.6%
7/08	0.214	0.102	0.151	0.184	0.147	0.228	0.242	0.141	0.196	0.166	0.176	0.017	0.137	0.215	22.2%
7/09	0.214	0.121	0.169	0.211	0.204	0.280	0.242	0.164	0.219	0.188	0.201	0.017	0.161	0.240	19.7%
7/10	0.237	0.148	0.188	0.250	0.252	0.280	0.269	0.188	0.246	0.240	0.226	0.016	0.189	0.264	16.5%
7/11	0.260	0.180	0.209	0.299	0.252	0.323	0.297	0.215	0.282	0.311	0.254	0.018	0.214	0.295	15.8%
7/12	0.280	0.206	0.248	0.336	0.285	0.357	0.331	0.243	0.326	0.311	0.286	0.019	0.244	0.328	14.7%
7/13	0.306	0.278	0.298	0.336	0.314	0.394	0.361	0.300	0.326	0.348	0.324	0.014	0.293	0.354	9.4%
7/14	0.367	0.354	0.298	0.387	0.352	0.425	0.422	0.366	0.383	0.382	0.371	0.014	0.339	0.404	8.8%
7/15	0.431	0.354	0.350	0.418	0.384	0.484	0.490	0.366	0.427	0.425	0.410	0.020	0.365	0.454	10.9%
7/16	0.431	0.413	0.376	0.450	0.445	0.530	0.490	0.403	0.466	0.465	0.442	0.017	0.403	0.481	8.9%
7/17	0.462	0.477	0.426	0.491	0.491	0.530	0.542	0.451	0.504	0.518	0.484	0.014	0.453	0.515	6.4%
7/18	0.506	0.503	0.470	0.547	0.491	0.583	0.590	0.483	0.576	0.572	0.522	0.016	0.485	0.558	7.0%
7/19	0.556	0.525	0.525	0.595	0.583	0.618	0.645	0.532	0.674	0.572	0.572	0.016	0.536	0.609	6.3%
7/20	0.594	0.556	0.590	0.595	0.620	0.638	0.679	0.581	0.674	0.622	0.607	0.014	0.576	0.637	5.0%
7/21	0.649	0.575	0.590	0.633	0.659	0.678	0.766	0.641	0.714	0.672	0.649	0.021	0.602	0.696	7.2%
7/22	0.705	0.575	0.615	0.654	0.689	0.727	0.836	0.641	0.762	0.723	0.680	0.028	0.616	0.744	9.4%
7/23	0.705	0.616	0.649	0.686	0.741	0.761	0.836	0.682	0.827	0.753	0.710	0.024	0.654	0.765	7.8%
7/24	0.741	0.663	0.696	0.727	0.785	0.761	0.881	0.722	0.840	0.789	0.747	0.023	0.694	0.799	7.0%
7/25	0.778	0.717	0.746	0.790	0.785	0.807	0.930	0.759	0.855	0.825	0.789	0.022	0.738	0.840	6.4%
7/26	0.801	0.761	0.812	0.840	0.827	0.838	0.975	0.804	0.873	0.825	0.832	0.022	0.782	0.883	6.1%
7/27	0.842	0.845	0.874	0.840	0.858	0.875	0.986	0.852	0.873	0.860	0.871	0.017	0.833	0.910	4.4%
7/28	0.894	0.903	0.874	0.884	0.892	0.915	0.992	0.967	0.891	0.894	0.915	0.015	0.881	0.949	3.7%
7/29	0.957	0.903	0.923	0.920	0.929	0.960	0.996	0.967	0.902	0.934	0.944	0.011	0.920	0.969	2.6%
7/30	0.957	0.962	0.959	0.959	0.967	1.000	0.996	0.990	0.957	0.967	0.974	0.006	0.959	0.988	1.5%
7/31	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.0%

[a] Relative precision.

Appendix B3. Historical daily cumulative proportions of the harvest of chinook salmon by unguided anglers during the return of late-run chinook salmon to the Kenai River, 1984-1993.

	Daily cumulative proportions [P(t)] by year of unguided angler harvest												95% Confidence Interval		
Date	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean	SE	Low	High	Rel[a] Prec
7/01	0.002	0.002	0.017	0.002	0.028	0.022	0.071	0.000	0.015	0.019	0.018	0.008	0.000	0.037	106.8%
7/02	0.011	0.002	0.025	0.002	0.037	0.049	0.071	0.024	0.032	0.023	0.028	0.009	0.008	0.047	69.6%
7/03	0.027	0.002	0.037	0.102	0.044	0.049	0.157	0.031	0.041	0.030	0.056	0.018	0.017	0.096	70.6%
7/04	0.044	0.003	0.042	0.119	0.044	0.064	0.168	0.031	0.050	0.051	0.064	0.019	0.022	0.107	66.2%
7/05	0.060	0.003	0.082	0.193	0.056	0.084	0.168	0.033	0.060	0.051	0.085	0.023	0.033	0.137	60.9%
7/06	0.067	0.025	0.088	0.193	0.070	0.125	0.245	0.038	0.060	0.109	0.106	0.027	0.045	0.168	57.8%
7/07	0.083	0.031	0.088	0.213	0.090	0.193	0.253	0.069	0.067	0.124	0.127	0.028	0.063	0.192	50.3%
7/08	0.131	0.031	0.108	0.226	0.099	0.193	0.268	0.069	0.077	0.201	0.141	0.029	0.075	0.206	46.3%
7/09	0.131	0.044	0.115	0.250	0.120	0.350	0.268	0.115	0.102	0.238	0.174	0.036	0.092	0.257	47.3%
7/10	0.140	0.070	0.133	0.321	0.158	0.350	0.275	0.130	0.109	0.287	0.197	0.036	0.115	0.280	41.8%
7/11	0.149	0.112	0.174	0.328	0.158	0.460	0.275	0.142	0.124	0.379	0.225	0.042	0.129	0.321	42.8%
7/12	0.157	0.124	0.183	0.367	0.223	0.510	0.303	0.154	0.148	0.379	0.253	0.047	0.146	0.359	42.0%
7/13	0.165	0.165	0.242	0.367	0.284	0.569	0.328	0.154	0.148	0.439	0.284	0.049	0.172	0.396	39.4%
7/14	0.179	0.276	0.242	0.380	0.300	0.574	0.364	0.210	0.254	0.467	0.316	0.044	0.216	0.416	31.8%
7/15	0.225	0.276	0.385	0.419	0.351	0.574	0.487	0.210	0.284	0.511	0.366	0.045	0.264	0.468	27.8%
7/16	0.225	0.402	0.420	0.438	0.372	0.584	0.487	0.244	0.324	0.542	0.396	0.042	0.301	0.491	23.9%
7/17	0.294	0.459	0.457	0.476	0.394	0.584	0.593	0.356	0.406	0.586	0.451	0.037	0.368	0.534	18.4%
7/18	0.345	0.473	0.490	0.499	0.394	0.584	0.650	0.416	0.433	0.632	0.481	0.035	0.401	0.561	16.6%
7/19	0.401	0.473	0.516	0.529	0.476	0.663	0.711	0.426	0.466	0.632	0.524	0.039	0.436	0.612	16.8%
7/20	0.485	0.488	0.543	0.529	0.510	0.663	0.718	0.480	0.466	0.656	0.552	0.032	0.480	0.624	13.0%
7/21	0.595	0.494	0.543	0.565	0.632	0.714	0.730	0.525	0.531	0.685	0.600	0.031	0.531	0.669	11.5%
7/22	0.705	0.494	0.548	0.596	0.731	0.725	0.832	0.525	0.562	0.709	0.644	0.043	0.548	0.741	14.9%
7/23	0.705	0.565	0.574	0.615	0.774	0.751	0.832	0.539	0.806	0.722	0.669	0.039	0.581	0.757	13.2%
7/24	0.771	0.602	0.623	0.670	0.827	0.751	0.932	0.596	0.818	0.744	0.721	0.042	0.625	0.817	13.3%
7/25	0.820	0.674	0.683	0.704	0.827	0.758	0.971	0.596	0.822	0.779	0.754	0.041	0.661	0.848	12.4%
7/26	0.835	0.755	0.731	0.752	0.902	0.784	0.989	0.664	0.822	0.779	0.802	0.037	0.719	0.884	10.3%
7/27	0.860	0.838	0.794	0.752	0.913	0.800	1.000	0.779	0.822	0.839	0.842	0.029	0.777	0.907	7.7%
7/28	0.881	0.935	0.794	0.813	0.915	0.964	1.000	0.954	0.822	0.893	0.907	0.026	0.849	0.965	6.4%
7/29	0.936	0.935	0.875	0.858	0.947	0.981	1.000	0.954	0.822	0.936	0.936	0.017	0.897	0.974	4.1%
7/30	0.936	0.972	0.926	0.903	0.969	1.000	1.000	0.987	0.901	0.970	0.962	0.013	0.933	0.990	3.0%
7/31	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.0%

[a] Relative precision.

Appendix B4. Historical daily cumulative proportions of the catch of chinook salmon by unguided anglers during the return of late-run chinook salmon to the Kenai River, 1984-1993.

	Daily cumulative proportions [P(t)] by year of unguided angler catch												95% Confidence Interval		
Date	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean	SE	Low	High	Rel[a] Prec
7/01	0.002	0.002	0.013	0.001	0.021	0.014	0.057	0.000	0.063	0.016	0.014	0.007	0.000	0.029	110.3%
7/02	0.009	0.002	0.017	0.001	0.029	0.044	0.057	0.033	0.076	0.030	0.024	0.007	0.008	0.040	66.9%
7/03	0.023	0.003	0.034	0.077	0.039	0.044	0.115	0.039	0.081	0.037	0.047	0.012	0.019	0.074	59.0%
7/04	0.040	0.003	0.048	0.106	0.039	0.094	0.122	0.046	0.088	0.058	0.062	0.014	0.030	0.095	51.9%
7/05	0.061	0.003	0.080	0.173	0.048	0.133	0.122	0.052	0.094	0.058	0.084	0.019	0.040	0.128	52.1%
7/06	0.072	0.018	0.089	0.173	0.064	0.163	0.200	0.059	0.094	0.109	0.105	0.023	0.053	0.157	49.7%
7/07	0.100	0.024	0.089	0.191	0.090	0.227	0.217	0.084	0.110	0.123	0.128	0.026	0.069	0.187	46.3%
7/08	0.137	0.024	0.122	0.205	0.102	0.227	0.235	0.084	0.116	0.204	0.142	0.026	0.082	0.202	42.0%
7/09	0.137	0.038	0.128	0.230	0.124	0.327	0.235	0.123	0.145	0.250	0.168	0.032	0.095	0.240	43.1%
7/10	0.144	0.066	0.138	0.283	0.178	0.327	0.245	0.136	0.157	0.324	0.190	0.031	0.120	0.260	36.9%
7/11	0.153	0.112	0.174	0.295	0.178	0.420	0.259	0.146	0.177	0.407	0.217	0.036	0.136	0.299	37.5%
7/12	0.160	0.127	0.180	0.344	0.256	0.487	0.313	0.156	0.200	0.407	0.253	0.043	0.154	0.351	38.9%
7/13	0.168	0.159	0.270	0.344	0.336	0.524	0.340	0.156	0.200	0.465	0.287	0.045	0.186	0.389	35.4%
7/14	0.180	0.276	0.270	0.370	0.356	0.529	0.393	0.203	0.281	0.500	0.322	0.040	0.231	0.413	28.2%
7/15	0.218	0.276	0.444	0.402	0.395	0.529	0.475	0.203	0.301	0.554	0.368	0.043	0.270	0.465	26.4%
7/16	0.218	0.414	0.470	0.424	0.415	0.539	0.475	0.294	0.333	0.579	0.406	0.037	0.323	0.489	20.4%
7/17	0.301	0.484	0.505	0.471	0.433	0.539	0.662	0.388	0.381	0.614	0.473	0.038	0.388	0.558	18.0%
7/18	0.372	0.497	0.528	0.499	0.433	0.672	0.707	0.439	0.422	0.656	0.518	0.041	0.425	0.612	18.0%
7/19	0.430	0.499	0.545	0.530	0.529	0.723	0.748	0.446	0.450	0.656	0.556	0.042	0.462	0.651	17.0%
7/20	0.509	0.516	0.559	0.530	0.556	0.723	0.763	0.500	0.450	0.675	0.582	0.036	0.500	0.664	14.0%
7/21	0.598	0.522	0.559	0.571	0.669	0.755	0.790	0.538	0.488	0.699	0.625	0.036	0.544	0.707	13.0%
7/22	0.718	0.522	0.566	0.598	0.754	0.773	0.874	0.538	0.526	0.726	0.668	0.046	0.564	0.772	15.5%
7/23	0.718	0.587	0.586	0.617	0.787	0.795	0.874	0.549	0.675	0.737	0.689	0.043	0.593	0.786	14.0%
7/24	0.778	0.625	0.619	0.663	0.834	0.795	0.948	0.614	0.709	0.754	0.734	0.043	0.636	0.833	13.4%
7/25	0.826	0.683	0.679	0.704	0.834	0.799	0.981	0.614	0.747	0.785	0.765	0.042	0.671	0.859	12.3%
7/26	0.846	0.754	0.719	0.757	0.912	0.833	0.992	0.671	0.792	0.785	0.811	0.038	0.726	0.896	10.5%
7/27	0.871	0.833	0.770	0.757	0.923	0.843	1.000	0.768	0.792	0.845	0.845	0.030	0.778	0.913	8.0%
7/28	0.898	0.907	0.770	0.823	0.927	0.973	1.000	0.960	0.829	0.899	0.907	0.027	0.845	0.969	6.8%
7/29	0.946	0.907	0.847	0.867	0.951	0.984	1.000	0.960	0.874	0.945	0.933	0.019	0.889	0.976	4.7%
7/30	0.946	0.975	0.917	0.908	0.974	1.000	1.000	0.989	0.937	0.970	0.964	0.013	0.935	0.993	3.0%
7/31	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.0%

[a] Relative precision.

Appendix B5. Historical daily cumulative proportions of the effort by guided anglers during the return of late-run chinook salmon to the Kenai River, 1984-1993.

	Daily cumulative proportions [P(t)] by year of guided angler effort												95% Confidence Interval		
Date	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean	SE	Low	High	Rel[a] Prec
7/01	0.000	0.023	0.025	0.006	0.025	0.032	0.000	0.000	0.035	0.021	0.014	0.005	0.003	0.025	78.0%
7/02	0.014	0.029	0.039	0.028	0.045	0.032	0.000	0.033	0.059	0.046	0.028	0.005	0.016	0.039	41.8%
7/03	0.027	0.033	0.055	0.055	0.045	0.032	0.045	0.063	0.088	0.068	0.044	0.005	0.034	0.055	23.1%
7/04	0.047	0.044	0.079	0.077	0.045	0.073	0.076	0.092	0.109	0.068	0.067	0.006	0.052	0.081	21.9%
7/05	0.073	0.064	0.103	0.077	0.079	0.104	0.102	0.131	0.109	0.068	0.092	0.008	0.074	0.109	19.3%
7/06	0.123	0.087	0.103	0.077	0.111	0.140	0.134	0.162	0.109	0.107	0.117	0.010	0.094	0.140	19.4%
7/07	0.199	0.087	0.103	0.107	0.138	0.179	0.173	0.162	0.151	0.128	0.143	0.014	0.111	0.176	22.8%
7/08	0.199	0.087	0.152	0.129	0.173	0.213	0.173	0.162	0.188	0.162	0.161	0.014	0.129	0.193	19.7%
7/09	0.199	0.122	0.181	0.172	0.211	0.213	0.173	0.223	0.217	0.189	0.187	0.011	0.161	0.212	13.9%
7/10	0.252	0.169	0.206	0.204	0.211	0.213	0.232	0.263	0.250	0.232	0.219	0.011	0.195	0.243	10.9%
7/11	0.320	0.228	0.242	0.225	0.211	0.276	0.290	0.309	0.291	0.232	0.263	0.015	0.229	0.296	12.6%
7/12	0.360	0.279	0.294	0.225	0.267	0.335	0.349	0.344	0.291	0.232	0.307	0.017	0.268	0.345	12.5%
7/13	0.412	0.322	0.294	0.225	0.319	0.388	0.409	0.388	0.291	0.292	0.345	0.023	0.292	0.398	15.3%
7/14	0.484	0.322	0.294	0.308	0.374	0.444	0.459	0.388	0.349	0.346	0.384	0.026	0.326	0.442	15.2%
7/15	0.484	0.322	0.339	0.384	0.408	0.493	0.459	0.388	0.398	0.397	0.410	0.023	0.358	0.461	12.5%
7/16	0.484	0.416	0.392	0.437	0.461	0.493	0.459	0.444	0.443	0.442	0.448	0.012	0.421	0.475	6.0%
7/17	0.534	0.485	0.455	0.486	0.461	0.493	0.507	0.509	0.475	0.485	0.491	0.009	0.471	0.512	4.2%
7/18	0.609	0.530	0.510	0.538	0.461	0.565	0.628	0.551	0.521	0.485	0.549	0.019	0.506	0.592	7.8%
7/19	0.654	0.577	0.569	0.538	0.527	0.621	0.692	0.604	0.521	0.485	0.598	0.020	0.552	0.643	7.6%
7/20	0.723	0.627	0.569	0.538	0.591	0.674	0.736	0.655	0.521	0.555	0.639	0.025	0.582	0.696	8.9%
7/21	0.737	0.627	0.569	0.596	0.650	0.724	0.793	0.655	0.608	0.616	0.669	0.027	0.608	0.730	9.1%
7/22	0.737	0.627	0.617	0.630	0.685	0.774	0.793	0.655	0.669	0.674	0.690	0.025	0.634	0.745	8.1%
7/23	0.737	0.677	0.645	0.679	0.745	0.774	0.793	0.713	0.730	0.709	0.720	0.018	0.679	0.761	5.7%
7/24	0.793	0.731	0.705	0.735	0.745	0.774	0.866	0.767	0.763	0.760	0.765	0.018	0.725	0.804	5.2%
7/25	0.842	0.790	0.770	0.782	0.745	0.837	0.918	0.813	0.785	0.760	0.812	0.019	0.769	0.855	5.3%
7/26	0.874	0.841	0.829	0.782	0.807	0.884	0.962	0.859	0.785	0.760	0.855	0.019	0.811	0.899	5.2%
7/27	0.926	0.918	0.829	0.782	0.864	0.922	0.990	0.912	0.785	0.822	0.893	0.023	0.841	0.945	5.8%
7/28	0.951	0.918	0.829	0.842	0.915	0.961	0.995	0.912	0.825	0.870	0.915	0.020	0.870	0.961	5.0%
7/29	0.951	0.918	0.902	0.894	0.960	1.000	0.995	0.912	0.857	0.923	0.942	0.015	0.909	0.975	3.5%
7/30	0.951	0.960	0.961	0.944	1.000	1.000	0.995	0.960	0.929	0.967	0.971	0.008	0.953	0.990	1.9%
7/31	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.0%

[a] Relative precision.

Appendix B6. Historical daily cumulative proportions of the harvest for chinook salmon by guided anglers during the return of late-run chinook salmon to the Kenai River, 1984-1993.

	Daily cumulative proportions [P(t)] by year of guided angler harvest												95% Confidence Interval		
Date	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean	SE	Low	High	Rel[a] Prec
7/01	0.000	0.037	0.013	0.008	0.026	0.013	0.000	0.000	0.045	0.029	0.012	0.005	0.001	0.023	89.0%
7/02	0.008	0.039	0.019	0.041	0.034	0.013	0.000	0.031	0.059	0.047	0.023	0.005	0.011	0.035	52.4%
7/03	0.030	0.041	0.030	0.085	0.034	0.013	0.027	0.068	0.059	0.059	0.041	0.008	0.022	0.060	46.3%
7/04	0.055	0.047	0.049	0.118	0.034	0.060	0.072	0.079	0.066	0.059	0.064	0.009	0.043	0.085	32.4%
7/05	0.080	0.058	0.055	0.118	0.064	0.085	0.107	0.079	0.066	0.059	0.081	0.008	0.063	0.099	22.5%
7/06	0.128	0.079	0.055	0.118	0.111	0.136	0.167	0.129	0.066	0.097	0.115	0.012	0.088	0.143	24.0%
7/07	0.197	0.079	0.055	0.157	0.129	0.220	0.201	0.129	0.088	0.125	0.146	0.021	0.098	0.193	32.5%
7/08	0.197	0.079	0.088	0.179	0.169	0.241	0.201	0.129	0.118	0.187	0.160	0.020	0.115	0.206	28.4%
7/09	0.197	0.109	0.102	0.215	0.193	0.241	0.201	0.129	0.127	0.230	0.173	0.018	0.132	0.215	24.1%
7/10	0.223	0.155	0.109	0.237	0.193	0.241	0.237	0.154	0.155	0.298	0.194	0.018	0.154	0.233	20.5%
7/11	0.249	0.217	0.143	0.244	0.193	0.316	0.262	0.211	0.202	0.298	0.229	0.018	0.188	0.270	17.9%
7/12	0.264	0.248	0.164	0.244	0.271	0.367	0.343	0.234	0.202	0.298	0.267	0.023	0.216	0.318	19.1%
7/13	0.301	0.281	0.164	0.244	0.297	0.469	0.407	0.246	0.202	0.375	0.301	0.034	0.224	0.378	25.6%
7/14	0.332	0.281	0.164	0.297	0.346	0.496	0.442	0.246	0.311	0.440	0.326	0.037	0.241	0.410	26.0%
7/15	0.332	0.281	0.207	0.345	0.392	0.508	0.442	0.246	0.380	0.501	0.344	0.036	0.264	0.425	23.4%
7/16	0.332	0.374	0.283	0.387	0.424	0.508	0.442	0.321	0.418	0.552	0.384	0.026	0.325	0.442	15.2%
7/17	0.384	0.428	0.330	0.442	0.424	0.508	0.528	0.347	0.445	0.591	0.424	0.025	0.368	0.480	13.2%
7/18	0.438	0.444	0.407	0.475	0.424	0.635	0.649	0.422	0.469	0.591	0.487	0.035	0.408	0.565	16.1%
7/19	0.483	0.469	0.446	0.475	0.490	0.709	0.709	0.514	0.469	0.591	0.537	0.038	0.451	0.623	16.1%
7/20	0.578	0.493	0.446	0.475	0.529	0.720	0.734	0.571	0.469	0.608	0.568	0.038	0.482	0.654	15.2%
7/21	0.606	0.493	0.446	0.513	0.592	0.753	0.821	0.571	0.515	0.665	0.599	0.046	0.496	0.702	17.2%
7/22	0.606	0.493	0.495	0.541	0.680	0.809	0.821	0.571	0.596	0.684	0.627	0.046	0.522	0.732	16.7%
7/23	0.606	0.607	0.509	0.619	0.778	0.809	0.821	0.600	0.628	0.706	0.668	0.041	0.575	0.762	14.0%
7/24	0.688	0.675	0.561	0.682	0.778	0.809	0.882	0.647	0.628	0.737	0.715	0.036	0.634	0.797	11.4%
7/25	0.748	0.743	0.627	0.742	0.778	0.868	0.916	0.696	0.628	0.737	0.765	0.032	0.692	0.838	9.6%
7/26	0.820	0.761	0.664	0.742	0.863	0.899	0.969	0.754	0.628	0.737	0.809	0.035	0.730	0.888	9.7%
7/27	0.903	0.876	0.664	0.742	0.905	0.943	0.983	0.848	0.628	0.812	0.858	0.037	0.773	0.943	9.9%
7/28	0.924	0.876	0.664	0.794	0.923	1.000	0.985	0.848	0.633	0.882	0.877	0.039	0.789	0.964	10.0%
7/29	0.924	0.876	0.818	0.853	0.956	1.000	0.985	0.848	0.633	0.917	0.907	0.024	0.853	0.962	6.0%
7/30	0.924	0.936	0.924	0.906	1.000	1.000	0.985	0.945	0.843	0.983	0.952	0.013	0.923	0.982	3.1%
7/31	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.0%

[a] Relative precision.

Appendix B7. Historical daily cumulative proportions of the catch for chinook salmon by guided anglers during the return of late-run chinook salmon to the Kenai River, 1984-1993.

	Daily cumulative proportions [P(t)] by year of guided angler catch												95% Confidence Interval		
Date	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean	SE	Low	High	Rel[a] Prec
7/01	0.000	0.031	0.017	0.006	0.019	0.011	0.000	0.000	0.036	0.024	0.011	0.004	0.002	0.020	85.5%
7/02	0.010	0.033	0.027	0.040	0.025	0.011	0.000	0.033	0.045	0.044	0.022	0.005	0.011	0.034	50.0%
7/03	0.026	0.034	0.036	0.080	0.025	0.011	0.030	0.063	0.045	0.062	0.038	0.008	0.020	0.056	47.1%
7/04	0.047	0.038	0.059	0.114	0.025	0.049	0.064	0.072	0.051	0.062	0.059	0.010	0.037	0.080	36.7%
7/05	0.072	0.045	0.069	0.114	0.051	0.080	0.095	0.092	0.051	0.062	0.077	0.008	0.059	0.096	23.9%
7/06	0.117	0.061	0.069	0.114	0.094	0.125	0.148	0.132	0.051	0.098	0.108	0.011	0.083	0.132	22.7%
7/07	0.176	0.061	0.069	0.160	0.112	0.193	0.181	0.132	0.067	0.124	0.136	0.018	0.095	0.176	30.1%
7/08	0.176	0.061	0.114	0.179	0.141	0.217	0.181	0.132	0.088	0.176	0.150	0.017	0.111	0.189	25.8%
7/09	0.176	0.115	0.127	0.217	0.160	0.217	0.181	0.136	0.095	0.217	0.166	0.014	0.135	0.197	18.7%
7/10	0.202	0.181	0.135	0.234	0.160	0.217	0.208	0.165	0.132	0.281	0.188	0.012	0.161	0.214	14.2%
7/11	0.239	0.257	0.163	0.241	0.160	0.320	0.234	0.218	0.166	0.281	0.229	0.018	0.188	0.270	18.0%
7/12	0.256	0.280	0.182	0.241	0.234	0.376	0.315	0.241	0.166	0.281	0.266	0.021	0.219	0.312	17.7%
7/13	0.285	0.315	0.182	0.241	0.260	0.493	0.377	0.251	0.166	0.355	0.300	0.034	0.223	0.378	25.7%
7/14	0.316	0.315	0.182	0.282	0.314	0.516	0.415	0.251	0.259	0.421	0.324	0.036	0.242	0.405	25.2%
7/15	0.316	0.315	0.249	0.335	0.365	0.535	0.415	0.251	0.314	0.490	0.348	0.033	0.273	0.423	21.5%
7/16	0.316	0.443	0.345	0.377	0.391	0.535	0.415	0.363	0.349	0.547	0.398	0.024	0.344	0.453	13.7%
7/17	0.382	0.507	0.409	0.428	0.391	0.535	0.504	0.395	0.374	0.585	0.444	0.022	0.395	0.493	11.1%
7/18	0.452	0.521	0.468	0.454	0.391	0.655	0.676	0.454	0.394	0.585	0.509	0.036	0.427	0.591	16.2%
7/19	0.503	0.538	0.501	0.454	0.451	0.724	0.738	0.533	0.394	0.585	0.555	0.040	0.465	0.646	16.3%
7/20	0.606	0.557	0.501	0.454	0.489	0.733	0.766	0.588	0.394	0.602	0.587	0.040	0.496	0.677	15.4%
7/21	0.631	0.557	0.501	0.494	0.610	0.763	0.837	0.588	0.427	0.657	0.623	0.043	0.526	0.720	15.6%
7/22	0.631	0.557	0.534	0.524	0.698	0.809	0.837	0.588	0.499	0.680	0.647	0.043	0.549	0.745	15.1%
7/23	0.631	0.665	0.545	0.598	0.788	0.809	0.837	0.613	0.523	0.700	0.686	0.039	0.598	0.774	12.8%
7/24	0.721	0.719	0.583	0.654	0.788	0.809	0.893	0.675	0.553	0.729	0.730	0.035	0.652	0.808	10.7%
7/25	0.777	0.780	0.641	0.735	0.788	0.860	0.937	0.724	0.576	0.729	0.780	0.031	0.709	0.851	9.1%
7/26	0.840	0.794	0.681	0.735	0.869	0.905	0.977	0.792	0.576	0.729	0.824	0.033	0.748	0.900	9.2%
7/27	0.912	0.910	0.681	0.735	0.921	0.945	0.987	0.878	0.576	0.808	0.871	0.038	0.786	0.956	9.8%
7/28	0.929	0.910	0.681	0.809	0.935	0.995	0.989	0.878	0.638	0.880	0.891	0.037	0.808	0.974	9.3%
7/29	0.929	0.910	0.826	0.861	0.962	1.000	0.989	0.878	0.659	0.920	0.919	0.022	0.870	0.969	5.4%
7/30	0.929	0.957	0.927	0.919	1.000	1.000	0.989	0.955	0.855	0.976	0.960	0.012	0.933	0.986	2.8%
7/31	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.0%

[a] Relative precision.

APPENDIX C

Supporting statistics of four run timing models used to predict river entry of late-run Kenai River chinook salmon, 1987-1993.

Appendix C. Comparison of four run timing models predicting river entry of late-run Kenai River chinook salmon, 1987-1993.

Year		Model											
1987		Mean Timing			Neap Tide			Curve Fit			Commercial Harvest		
Date	Inriver Return	Proj[a]	Diff[b]	SQ of Diff[c]	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff
15-Jul	48123	26141	-21982	483210488	36919	-11204	125524091	55800	7677	58936329	46885	-1238	1532644
16-Jul	48123	27504	-20619	425131063	36628	-11495	132126328	55500	7377	54420129	47786	-337	113569
17-Jul	48123	28102	-20021	400860299	36124	-11999	143976553	53300	5177	26801329	50342	2219	4923961
18-Jul	48123	27372	-20751	430620603	33982	-14141	199962182	48800	677	458329	47102	-1021	1042441
19-Jul	48123	30023	-18100	327605155	35554	-12569	157988232	48600	477	227529	48942	819	670761
20-Jul	48123	35361	-12762	162866605	40534	-7589	57586187	49800	1677	2812329	51985	3862	14915044
21-Jul	48123	40147	-7976	63623346	43695	-4428	19607490	52200	4077	16621929	52861	4738	22448644
22-Jul	48123	41701	-6422	41236453	43554	-4569	20875597	54200	6077	36929929	53160	5037	25371369
23-Jul	48123	42013	-6110	37334976	43089	-5034	25341460	55100	6977	48678529	54075	5952	35426304
24-Jul	48123	44312	-3811	14523142	45377	-2746	7542940	56500	8377	70174129	55612	7489	56085121
25-Jul	48123	45102	-3021	9128327	45928	-2195	4817361	57000	8877	78801129	58166	10043	100861849
		SUM	715-725	2396140458	SUM	715-725	895348422	SUM	715-725	394861619	SUM	715-725	263391707
			720-725	328712849		720-725	135771036		720-725	254017974		720-725	255108331

Year		Model											
1988		Mean Timing			Neap Tide			Curve Fit			Commercial Harvest		
Date	Inriver Return	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	CF Proj	Diff	SQ of Diff
15-Jul	52008	50332	1676	2807347	117168	-65160	4245828720	75300	-23292	542517264	40946	11062	122367844
16-Jul	52008	48481	3527	12441499	110346	-58338	3403323649	76300	-24292	590101264	43096	8912	79423744
17-Jul	52008	47372	4636	21496239	105830	-53822	2896842589	77000	-24992	624600064	44855	7153	51165409
18-Jul	52008	48208	3800	14439703	94586	-42578	1812847219	77500	-25492	649842064	44465	7543	56896849
19-Jul	52008	48727	3281	10764354	91417	-39409	1553086279	76900	-24892	619611664	41873	10135	102718225
20-Jul	52008	50546	1462	2136253	90635	-38627	1492067875	76400	-24392	594969664	39324	12684	160883856
21-Jul	52008	53235	-1227	1506484	82755	-30747	945355256	76700	-24692	609694864	37338	14670	215208900
22-Jul	52008	53139	-1131	1279405	76238	-24230	587116299	76800	-24792	614643264	40135	11873	140968129
23-Jul	52008	52348	-340	115708	69123	-17115	292914943	75900	-23892	570827664	41571	10437	108930969
24-Jul	52008	51155	853	727754	64773	-12765	162950920	75200	-23192	537868864	41948	10060	101203600
25-Jul	52008	50055	1953	3812265	60872	-8864	78576341	73600	-21592	466214464	42828	9180	84272400
		SUM	715-725	71527011	SUM	715-725	17470910090	SUM	715-725	6420891104	SUM	715-725	1224039925
			720-725	9577869		720-725	3558981634		720-725	3394218784		720-725	811467854

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Year 1989

		Model											
		Mean Timing			Neap Tide			Curve Fit			Commercial Harvest		
Date	Inriver Return	Proj[a]	Diff[b]	SQ of Diff[c]	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff
15-Jul	29035	60023	30988	960287026	31616	2581	6659490	90900	61865	3827278225	33855	4820	23232400
16-Jul	29035	57582	28547	814921337	31563	2528	6389343	89300	60265	3631870225	31919	2884	8317456
17-Jul	29035	53816	24781	614076949	31003	1968	3871255	87600	58565	3429859225	33565	4530	20520900
18-Jul	29035	52151	23116	534355208	31563	2528	6392497	85700	56665	3210922225	32170	3135	9828225
19-Jul	29035	49073	20038	401531169	30819	1784	3181409	82600	53565	2869209225	30684	1649	2719201
20-Jul	29035	46688	17653	311635094	30520	1485	2204244	79200	50165	2516527225	31976	2941	8649481
21-Jul	29035	44955	15920	253457476	30594	1559	2429103	76300	47265	2233980225	32955	3920	15366400
22-Jul	29035	43836	14801	219080030	30300	1265	1601471	73800	44765	2003905225	32017	2982	8892324
23-Jul	29035	42268	13233	175101841	30161	1126	1268692	71800	42765	1828845225	33146	4111	16900321
24-Jul	29035	40707	11672	136226399	30083	1048	1098737	68600	39565	1565389225	34586	5551	30813601
25-Jul	29035	39307	10272	105516392	29751	716	512612	65900	36865	1359028225	35773	6738	45400644
		SUM	715-725	4526188921	SUM	715-725	35608854	SUM	715-725	28476814475	SUM	715-725	190640953
			720-725	1201017231		720-725	9114860		720-725	11507675350		720-725	126022771

Year 1990

		Model											
		Mean Timing			Neap Tide			Curve Fit			Commercial Harvest		
Date	Inriver Return	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff
15-Jul	33474	34081	-607	369046	30224	3250	10559522	56300	-22826	521026276	6178	27296	745071616
16-Jul	33474	33369	105	11089	29397	4077	16624023	56200	-22726	516471076	7996	25478	649128484
17-Jul	33474	36576	-3102	9622715	31976	1498	2242759	56900	-23426	548777476	7367	26107	681575449
18-Jul	33474	38507	-5033	25326833	32653	821	674843	58400	-24926	621305476	9640	23834	568059556
19-Jul	33474	38986	-5512	30379085	32562	912	830867	58500	-25026	626300676	8818	24656	607918336
20-Jul	33474	39101	-5627	31662376	32700	774	598399	58500	-25026	626300676	10905	22569	509359761
21-Jul	33474	37686	-4212	17742461	31715	1759	3093851	57700	-24226	586899076	12439	21035	442471225
22-Jul	33474	36910	-3436	11804729	30753	2721	7403973	56900	-23426	548777476	12081	21393	457660449
23-Jul	33474	35608	-2134	4554373	30414	3060	9361681	55600	-22126	489559876	13528	19946	397842916
24-Jul	33474	35100	-1626	2642341	30573	2901	8417347	54500	-21026	442092676	13050	20424	417139776
25-Jul	33474	34567	-1093	1193938	30458	3016	9097601	53000	-19526	381264676	13181	20293	411805849
		SUM	715-725	135308985	SUM	715-725	68904864	SUM	715-725	5908775436	SUM	715-725	5888033417
			720-725	69600218		720-725	37972852		720-725	3074894456		720-725	2636279976

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Appendix C. (Page 3 of 4).

Year 1991

		Model											
		Mean Timing			Neap Tide			Curve Fit			Commercial Harvest		
Date	Inriver Return	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff
15-Jul	34614	16153	18461	340805936	26548	8066	65058569	29900	4714	22221796	25178	9436	89038096
16-Jul	34614	17320	17294	299090374	27583	7031	49431417	30100	4514	20376196	22197	12417	154181889
17-Jul	34614	20836	13778	189830418	31431	3183	10131758	31500	3114	9696996	20360	14254	203176516
18-Jul	34614	26425	8189	67056955	38600	-3986	15890567	35600	-986	972196	19741	14873	221206129
19-Jul	34614	29154	5460	29814065	40197	-5583	31166769	38300	-3686	13586596	22042	12572	158055184
20-Jul	34614	29804	4810	23132295	39421	-4807	23105986	38600	-3986	15888196	22461	12153	147695409
21-Jul	34614	29591	5023	25232326	37225	-2611	6819350	37800	-3186	10150596	20654	13960	194881600
22-Jul	34614	30151	4463	19921207	34713	-99	9832	37100	-2486	6180196	19688	14926	222785476
23-Jul	34614	32989	1625	2639216	37238	-2624	6885345	37200	-2586	6687396	18571	16043	257377849
24-Jul	34614	34582	32	1005	38458	-3844	14773421	37200	-2586	6687396	18082	16532	273307024
25-Jul	34614	34906	-292	85254	38038	-3424	11722754	37100	-2486	6180196	17564	17050	290702500
		SUM	715-725	997609051	SUM	715-725	234995769	SUM	715-725	118627756	SUM	715-725	2212407672
			720-725	71011304		720-725	63316689		720-725	51773976		720-725	1386749858

Year 1992

		Model											
		Mean Timing			Neap Tide			Curve Fit			Commercial Harvest		
Date	Inriver Return	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff
15-Jul	30314	17783	12531	157020281	48322	-18008	324297813	34000	-3686	13586596	29212	1102	1214404
16-Jul	30314	17858	12456	155144439	46052	-15738	247675992	34300	-3986	15888196	30765	-451	203401
17-Jul	30314	17433	12881	165930325	44105	-13791	190190229	29800	514	264196	33384	-3070	9424900
18-Jul	30314	17775	12539	157219796	43248	-12934	167286495	30100	214	45796	33989	-3675	13505625
19-Jul	30314	19014	11300	127680248	42749	-12435	154627658	30200	114	12996	31042	-728	529984
20-Jul	30314	19835	10479	109806577	40394	-10080	101608237	29500	814	662596	32827	-2513	6315169
21-Jul	30314	19886	10428	108733411	37398	-7084	50181564	18300	12014	144336196	33569	-3255	10595025
22-Jul	30314	20061	10253	105115507	34349	-4035	16279184	18500	11814	139570596	34534	-4220	17808400
23-Jul	30314	21289	9025	81453865	34404	-4090	16728059	20900	9414	88623396	32915	-2601	6765201
24-Jul	30314	21031	9283	86167113	31973	-1659	2752369	21100	9214	84897796	32581	-2267	5139289
25-Jul	30314	22639	7675	58910241	31752	-1438	2067615	21600	8714	75933796	31659	-1345	1809025
		SUM	715-725	1313181803	SUM	715-725	1273695215	SUM	715-725	563822156	SUM	715-725	73310423
			720-725	550186714		720-725	189617028		720-725	534024376		720-725	48432109

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Year 1993		Model											
		Mean Timing			Neap Tide			Curve Fit			Commercial Harvest		
Date	Inriver Return	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff	Proj	Diff	SQ of Diff
15-Jul	49674	66112	-16438	270204934	35598	14076	198143690	69700	-20026	401040676	44790	4884	23853456
16-Jul	49674	66150	-16476	271457911	36908	12766	162983294	69200	-19526	381264676	45550	4124	17007376
17-Jul	49674	64732	-15058	226739343	37781	11893	141452866	68900	-19226	369639076	48512	1162	1350244
18-Jul	49674	61934	-12260	150315589	37895	11779	138754424	67900	-18226	332187076	49576	98	9604
19-Jul	49674	58936	-9262	85779572	37328	12346	152423492	66600	-16926	286489476	48289	1385	1918225
20-Jul	49674	56940	-7266	52791459	37452	12222	149373366	95300	-45626	2081731876	48946	728	529984
21-Jul	49674	54507	-4833	23362098	37257	12417	154180336	92400	-42726	1825511076	47314	2360	5569600
22-Jul	49674	54086	-4412	19462578	37515	12159	147837768	89900	-40226	1618131076	46905	2769	7667361
23-Jul	49674	52592	-2918	8515690	37605	12069	145650123	87100	-37426	1400705476	48090	1584	2509056
24-Jul	49674	51314	-1640	2689820	37944	11730	137588764	84600	-34926	1219825476	48399	1275	1625625
25-Jul	49674	52334	-2660	7077159	39599	10075	101498045	53100	-3426	11737476	47018	2656	7054336
		SUM	715-725	1118396152	SUM	715-725	1629886167	SUM	715-725	9928263436	SUM	715-725	69094867
			720-725	113898804		720-725	836128401		720-725	8157642456		720-725	24955962

[a] Projected end-of-season inriver return.
[b] Difference between projected value and end-of-season inriver return.
[c] Squared difference between projected value and realized value.